RISK MANAGEMENT SYSTEM TO GUIDE BUILDING CONSTRUCTION PROJECTS' IN DEVELOPING COUNTRIES: A CASE STUDY OF NIGERIA

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ABSTRACT

Project risk assessment is an effective tool for planning and controlling cost, time and achieving the technical performance of a building construction project. Construction projects often face a lot of uncertainties, which places building construction projects at the risk of cost, time overruns as well as poor quality delivery. Considering the limited resources of developing countries, there is need to complete building projects on-time, on-budget, and to meet optimal quality hence, risk management is an important part of the decision making process in construction industry as it determines the success or failure of construction projects. In line with this need, this research aims to establish a system to improve the time, cost and quality performance of building construction projects in developing countries, through a comprehensive risk management model that ensures the expectations of clients are met.

To achieve the aim of this research, a mixed methodological approach was adopted. Through the review of literature, a conceptual risk management framework suitable to elaborate risk assessment of building construction projects especially for developing countries was developed. A questionnaire survey using a nonprobability sampling technique was conducted to elicit information from construction professionals in Nigeria to assess their perception of 79 risk factors identified from literature review based on the likelihood of occurrence and impact on projects using a five point scale. Responses from 343 construction professionals were drawn from 305 contractors and subcontractors and 38 clients (private and public) within the Nigerian construction sector. Response data was subjected to descriptive statistics to depict the frequency distribution and central tendency of responses. Subsequently, the risk acceptability matrix (RAM) was adopted to categorise and prioritise risk factors. 27 critical risks that affect building construction projects were identified. A Bayesian Belief Network (BBN) model was developed by structural learning and used to examine the cause and effect relationship amongst the 27 critical risk factors. The developed BBN model was subjected to validation using a multiple case study of two building construction projects in Nigeria. The result showed the interrelation between the 27 risk factors and how they contributed to cost and time overruns as well as quality problems. The critical risks directly affecting the cost of building construction project were: fluctuation of material prices; health and safety issues; bribery and corruption; material wastage; poor site management and supervision; and time overruns. The critical factors identified to directly affect quality were: supply of defective materials; working under harsh conditions; improper construction methods; lack of protective equipment; ineffective time allocation; poor communication between involved stakeholders; and unsuitable leadership style. Time overruns on building construction projects was directly caused by: quality problems; low productivity; improper construction methods; poor communication between involved parties; delayed payments in contracts; and poor site management and supervision.

As a consolidation of the findings of this research, a BBN model for identifying risk factors that directly affect time, cost and quality on building construction projects has been developed which has the potential for assisting construction stake holders to manage risks on their projects. In view of the findings, a best practice system for risk management in building construction projects in Nigeria has been developed with an implementation guide to help building construction practitioners to successfully implement risk management on their building construction projects. Suitable risk responses, also in the form of recommendations have been identified. The strategies include actions to be taken to respond to risks based on their perceived significance or acceptability as well as some positive risk responses, such as exploiting, sharing, enhancing and accepting, and other negative risk responses, such as avoidance, mitigation transfer and acceptance

DEDICATION

I dedicate this thesis to the HOLY SPIRIT who granted me the understanding and grace to embark upon and complete this PhD Programme.

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GLOSSARY OF TERMS

EVENT	A possible future situation
CERTAINTY	A predictable future event
UNCERTAINTY	Unpredictable future event
THREAT	A possibility for financial loss
OPPORTUNITY	A possibility for financial gain
RISK	An event whose exact likelihood and consequences is uncertain, if it risk occurs, could cause a threat or opportunity to an organisation.
MAGNITUDE OF IMPACT	The extent to which a risk factor could affect the project performance should this risk occur.
RISK LIKELIHOOD	The frequency of occurrence of a risk factor.
CONCEPTUAL FRAMEWORK	An analytical tool with several variations and contexts. It is used to make conceptual distinctions and organize ideas. Strong conceptual frameworks capture something real and do this in a way that is easy to remember and apply.
SYSTEM	A set of detailed method, procedure and routine created to carry out a specific activity, perform a duty, or solve a problem.
MODEL	A graphical, mathematical, physical or verbal representation or simplified version of a concept, phenomenon, relationship, structure or an aspect of the real world.
BBN	Bayesian Belief Network
RAM	Risk Acceptability Matrix
RBS	Risk Breakdown Structure
BUILDING CONSTRUCTION PROJECT	In this research, it is associated with the technique and industry involved in the assembly and erection of structures, primarily those used to provide shelter. E.g. housing, churches, hospitals, offices, shopping mall etc.
SPSS	Statistical Package For Social Science

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CHAPTER ONE: INTRODUCTION TO THE RESEARCH STUDY

1.0 Chapter Introduction

This chapter presents an outline of the research with discussions centred on the background of the study, the Nigerian construction industry, the research problem, the purpose of the study as well as the research questions to be answered. The discussion of the research objectives, the methodology and the research scope and motivation are also presented. The chapter concludes with a summary of how the thesis was structured.

1.1 Background of the Study

Buildings have been considered as one of the most valuable assets of a nation to provide people with shelter and facilities for work and leisure (Lam, Chan and Chan, 2010). Building construction projects are some of the most dynamic, risky and complex endeavours (Kangari, 1995; Mills, 2001). Building construction projects which are associated with housing, offices, hospitals, factories, churches etc. are unique and built only once. Consequently, the construction industry plays a key role in the economy of any nation, more so in a developing country like Nigeria. It is a vital contributor to the gross domestic product (GDP) growth and produces the built environment that supports other sectors of the economy in most part of the world (Oladapo, 2015; NELF, 2013). According to the Frontier Market Intelligence report (2012), the Nigerian construction industry experienced a growth rate of 20% between 2006 and 2007 and 13.1% between 2008 and 2012. The report however, highlighted that building construction in Nigeria accounted for 1.33% GDP in 2012 which is below the world average benchmark for 9% of GDP. This result leaves a huge room for growth in the construction of buildings across all sectors of the economy in Nigeria.

An overview of the traditional building construction process can be explained in four simple stages: conceptual design, construction, operation and maintenance. John et al (2005), explain these stages accordingly: conceptual stage comprises the client brief, the initial model of building and designs of services. They have to be agreed, before proceeding to the design stage proper where details of concepts are expanded and solutions derived. Each of the involved party (e.g. clients, architects, engineers and quantity surveyors, etc.) will produce the required information about the designs that can be passed onto the next stage. In the construction stage, contractors will make use of this information and, on completion of the building the operation and maintenance requirements of the building will come into action. This is when the building will be managed and maintained, by either the estate department or facilities management team.

However, the passage from one stage to another is not all “smooth-sailing”, but is fragmented, complicated, risky and uncertain (Arayici, Egbu and Coates, 2012; John et al, 2005). The cost of risk is a concept many construction companies have never thought about despite the fact that it is one of the largest expense items (Cavignac, 2009). Risk management helps the key project participants - client, contractor or developer, consultant, and supplier - to meet their commitments and minimize negative impacts on construction project performance in relation to cost, time and quality objectives (Banaitiene, Banaitis and Norkus, 2011). The presence of an effective and efficient construction risk management function will enhance the successful completion of building construction projects and thereby make the project more profitable. On the contrary, the absence of an effective risk management process has several negative consequences for participants in a building project due to lack of preventive action against the risks and uncertainty that any project presents (Serpella, Ferrada, Howard and Rubio, 2014).

1.2 Nigerian Construction Industry

Nigeria, officially referred to as the Federal Republic of Nigeria, is a country in West Africa that shares land borders with the Republic of Benin in the West, Chad and Cameroon in the East, Niger in the North and borders of Gulf of Guinea in the South and the Atlantic Ocean (Internet World Stats, 2009). Nigeria consists of 36 States plus a Federal Capital Territory, while since 1991 the country’s capital has been centrally located in the city of Abuja.

The construction industry in developing countries like Nigeria can be categorised into two main groups as reported by Dantata (2008). This includes the organised and unorganised sector of the construction industry. The organised or sometimes called the formal sector of the construction industry constitute of all legally registered companies in the country that carry out organised construction projects with a combination of highly skilled expatriates and labourers. It is however evidenced that foreign construction companies dominate this construction market sector in developing countries most especially in Nigeria and most often, import equipment, materials and even labour (NELF, 2013). This construction sector operates under sets of rules and regulations, including adherence to national laws on employment, procurement, and tendering (Dantata, 2008). On the other hand, the unorganised or informal sector of the construction industry for which no accurate or reliable data is available on, comprised of simple residential building and similar structures built by private citizens and constructed through the effort of gangs of artisans and labour, hired mainly using multiple prime method of construction like the owner supervised construction (Dantata, 2008).

However, construction works in developing countries suffer from administrative and allocative inefficiencies because of the lack of a sound management framework especially among those affecting public procurement (The World Bank, 1984). The construction industry is not shaped to respond quickly to the needs of the clients which in most cases take far longer than expected and frequently fail to meet the technical performance of construction project. At the same time, distortions in prices and the rationing of materials and other inputs tend to cause allocative inefficiencies which make the works in hand economically more costly than they should be (The World Bank, 1984). The inadequate growth of construction capacity most especially the capacity to manage construction risks in developing countries is a problem the public and private sectors need to face.

1.3 Statement of Research Problem

Economic growth and socio-economic development are particularly important for developing countries; and the construction industry plays a central role in driving both of these. However, building construction projects have been identified as one of the most dynamic, risky and complex endeavours (Kangari, 1995; Mills, 2001).

A large number of building construction projects in developing countries suffer from many setbacks in terms of completion of the project at stipulated time, cost overruns and quality problems. These setbacks are often responsible for turning profitable projects into loosing ventures (Sweis, Sweis, Abu Hammad and Shboul, 2008). An example of the poor performance of building construction projects can be found in the Nigerian construction industry. According to Olusegun and Michael (2011), about 4000 uncompleted projects belonging to the Federal Republic of Nigeria with an estimated cost of over 300 Billion Naira (almost £1bn), will take 30 years to complete at the present execution capacity of the government. The failure to achieve targeted time, budgeted cost and specified quality result in various unexpected negative effects on building construction projects and thereby, has an appalling effect on the construction sector in particular to the national economy as a whole (Olusegun and Micheal, 2011).

An investigation carried out by Odeyinka and Yusuf (1997) shows that seven out of ten projects suffered delays and continuously failed to achieve the project goal of time, cost and quality, etc. Table 1.1 shows an inventory of failed projects in Nigeria.

Table 1.1: Inventory of abandoned projects in Ondo State of Nigeria
Source: Adesina, (2010)

Project title	**Location of site**	**Contract sum (Naira)**	**Year of commencement**	**Year of completion**	**Expected duration of contract**
A	Ondo-Akure	500m	1985	Not completed	12 months
B	Oba Ile	10m	2001	Not completed	Unknown
C	Alagbaka Akure	15m	2003	Not completed	Unknown
D	Akungba Akoko	11.5	2008	Not completed	Unknown
E	Alagbaka Akure	738m	2008	Not completed	10months
F	Ke Aro Akure	11.5m	2008	Not completed	6months
G	Kungba Akoko	14m	1999	Not completed	24months
H	Iju-Itaogbolu	3m	2004	Not completed	Unknown
I	Iyere Owo	11.5m	2008	Not completed	6 months
J	Owo	17m	2007	Not completed	18months
K	Okitipupa	800m	2007	Not completed	Unknown
L	Ode-Ekitan Ilaje	10m	2008	Not completed	Unknown
M	Ode-Ekitan Ilaje	8m	2008	Not completed	Unknown
N	Ode Aye	11.5m	2008	Not completed	6months

Okuwoga (1998) in his report showed that the performance of the building construction industry in Nigeria has consistently been a source of concern to both public and private sector clients. The results of the study carried out on 42 building projects executed by the Federal Government of Nigeria through the Federal Housing Authority, Ogun State Housing Corporation, Oyo State Ministry of Works and Housing, and Lagos State Property Development Corporation (LSDPC) shows that at the pre-contract stage of these projects, budgeted sums showed systematic under estimation of project costs, this was about 17% lower than realistic estimate. In addition, the time lag between the realistic estimate and actual commencement of contract accounted for some 12% underestimation. Accordingly, at the post-contract stage, the analysis showed that cost performance of sample projects, indicated overruns, of 15% for the first quarter of the sample, 20% for the first half and 30% for the first three-quarters. A further analysis of some of the projects based on cost components showed that works clearly defined in nature and scope before contract (measured work) accounted for about 50% of the total cost overruns, and works for which nature and extent could not be clearly defined, but fairly estimated (provisional sums), accounted for about 15% cost overrun.

Consequently, Oyewobi, Ibironke, Ganiyu and Ola-Awo (2011), pointed out that cost and time overruns have become a cankerworm within the Nigeria construction industry today as well as lack of good quality work of its end product, which do not provide many of the clients' value for money. Construction projects in Nigeria are known for overshooting their initial cost budget, which invariably means it is out of initial time schedule (Ogunsemi and Aje, 2005).

To address this challenge, risk management has become an important part of the decision-making process in construction industry - as it determines the success or failure of construction projects (Abujnah and Eaton, 2010). Good decisions are made against a predetermined set of objectives based on knowledge, data, and information; whereas decisions that are made without a logical assessment of project-specific criteria may lead to difficulties in project delivery (Abujnah and Eaton, 2010). As a result, risk and uncertainty can potentially have damaging consequences for all building projects. The ineffective handling of risks can be damaging not only to the contractor, but also to the project as a whole. Risk can affect productivity, performance, quality, and the budget of a project. Risk sometimes cannot be eliminated, but it can be minimized, transferred or retained (Smith, Merna, and Jobling, 2006).
However, failure in managing risk may not be peculiar to Nigeria alone, but may be reasonably justified for most developing countries.

1.4 Research Questions

As a result of these issues identified in section 1.3, the following research questions have been formulated. These are;

I. What is the level of understanding and the degree of implementation of risk management by the construction sector in developing countries?

II. What are the key critical risk factors associated with building construction projects in developing countries and what level of awareness do project managers have?

III. Are there any existing risk management measures that are being utilized to manage risk factors in building projects and how successful have these been applied?

IV. Is there a cost effective risk management model that guides companies in the construction sector in developing countries to identify, analyse and manage risk in their business environment?

1.5 Purpose of the Study

Based on the research questions and the aforementioned issues, the primary aim of this research therefore, is to establish a system which will help improve the performance of building construction projects in developing countries, without cost and time overruns while achieving optimal quality, through a comprehensive risk management model that ensures the expectations of clients are met.

1.6 Research Objectives

To successfully answer the research aim as stated in section 1.5, measurable research objectives have been developed. They are;

I. To recognise the relevant literature on the current level of building construction project performance in terms of cost, time and quality.

II. To identify through data collection the major risk factors that have significant effect on building construction project performance in developing countries.

III. To develop a robust user friendly risk management model that achieves a systematic and structured assessment and management of risk within building construction projects in developing countries with a view to enhancing client satisfaction and project completion without cost and time overruns.

IV. To validate the model using data from live building construction projects.

1.7 Research Methodology

The research methodology is the systematic and orderly steps taken towards the collection and analysis of data (Collis and Hussey, 2003). The research follows a mixed methods approach and involves four main stages as follows:

1. A review of the literatures to establish the knowledge gap in construction risk management.
2. Development of a questionnaire targeting the building construction sector in a developing country to acquire data on critical risk factors affecting their business operations.
3. Apply modelling and simulation techniques to understand how the risk factors affect performance. The Bayesian belief network is adapted to model risk assessment/management in building construction environments.
4. The exploration of two case studies involving interviews with project managers within construction organisations used to validate the survey and Bayesian belief network model outcomes.

1.8 Research Scope and Motivation

The research scope and motivation for undertaking the research are summarised in the following section

1.8.1 Research Scope

The scope of this research focuses on building construction in Nigeria. The research investigates the degree of implementation of risk management in building construction projects and further identifies key risk indicators that have significant effects on building construction projects. The research also evaluates the measurement of the likelihood of the risk event and the impact caused on building project performance. The research concentrates on building projects since they are considered as one of the most valuable assets of a nation, which provide people with shelter and facilities for work and leisure. The term “risk” in this research is referred to the negative consequences of the unforeseen event which is usually called threat.

1.8.2 Research Motivation

- There is, currently, a huge shortage of housing units in Nigeria. As a result, the Federal Government of Nigeria in 2013 launched the Nigeria Mortgage Refinance Company (NMRC), signalling the beginning of a process that would finally increase opportunities for building construction projects to realise its great potential for the good of the country. However, the Nigerian construction industry is concerned to recognise the main causes of poor project performance of their previous projects.

- The output of building construction enterprise in Nigeria is usually characterised by poor quality work, cost and time overruns. These characteristics originate because a number of risk factors have not been taken into consideration in the project planning and implementation stage. Hence, to address this challenge, a risk management system based on a systematic and structured assessment to support building construction projects is essential.
- The recent development of the Nigeria Mortgage Refinance Company (NMRC) creates an opportunity for international companies to invest in building projects in Nigeria. However, these foreign enterprises have no previous knowledge of the Nigerian construction environment. Therefore, this research is intended to provide a comprehensive model to help participants understand the main threats they might face.

1.9 Significance of Study

The construction industry in Nigeria provides infrastructural, economical and affordable housing for the Nigeria economy. Oladapo (2015) reports the industry has had a rapid and steady growth rate in the past two decades and also has one of the highest rates of expansion more than any sector of the Nigerian economy. As a result, there is urgent need for development of risk management systems for building construction projects. This political and economic instability bring opportunities for the researcher to develop an effective risk management technique to cope with risk associated with building construction activities and to implement building projects in line with defined project objectives of time, cost and quality. This risk management system will motivate stakeholders’ in terms of effective risk management and risk response development strategy. The findings will guide construction organisations in Nigeria and developing countries, particularly construction practitioners to abandon inappropriate risk control processes and implement better practice. It will further improve and open a new area of risk management research.

1.10 Structure of the Thesis

The thesis consists of eight chapters, each having an introduction and summary. The design of the chapters is intended to capture the flow of information about the key issues. Hence, each chapter leads into the development of an important part of this work. The structure of the thesis is illustrated in figure 1.0.

Chapter One: “Introduction” presents the background to the research problem, research aim and objective. In addition to the research scope and motivation, this chapter highlights the significance of the study. Finally, the research methodology provides the necessary steps for conducting this research. The thesis structure is also provided.

Chapter Two: “Construction Risk Management” presents an extensive literature review covering issues such as delay risks, causes and effects, and control measures. In addition, this chapter will examine the construction-related professional institutions frameworks to gain an understanding of the essential steps required for successful risk management.

Chapter Three: “Construction project performance, Risk Breakdown Structure and Risk Acceptability Matrix” presents a critical reflective evaluation on literature review on the causes of cost overruns, time overruns and quality problems in construction projects. Therefore, a list of risk factors that contribute to construction delay in developing countries will be assembled. Consequently, a risk breakdown structure (RBS) will be derived. Examining the construction-related professional institutions frameworks identifies the existing tools and techniques utilized for qualitative risk analysis. Thus, a risk acceptability matrix (RAM) will be developed.

Chapter four: “Research Methodology” adopted to execute the study is detailed. This involves a discussion of the research process and design, the sampling associated with the empirical work, and the way in which data was collected. Issues concerning the validity and reliability of the study and the code of ethics adhered to in carrying it out are also discussed.

Chapter Five: “Questionnaire Analysis” this chapter presents the first part of data analysis that deals with the quantitative data analysis. It illustrates the results of different sections of the questionnaire in tables and diagrams and provides explanations for each.

Chapter Six: “Application of The Bayesian Belief Network in Building Construction Projects” this chapter presents a BBN model to support risk management for building construction projects. The Bayesian belief network is used for knowledge representation and reasoning under conditions of uncertainty.

Chapter Seven: “Case Study: Validation” this chapter describes the validation process of the BBN model and the methodology adopted for validation procedure. As a result of the findings, a best practice risk management system was developed for building construction projects in Nigeria.

Chapter Eight: “Conclusion and Recommendation for Future Research” this final chapter, presents the conclusions of the research. It closes the thesis by providing answers to the research questions, including the achievement of the research aim and objectives as they were initially formulated. Subsequently, the chapter highlights the contributions made to existing knowledge and practice in construction risk project management. It further outlines the limitations of the research and also suggests possible recommendations for construction industry practitioners, and some recommendations for future research.

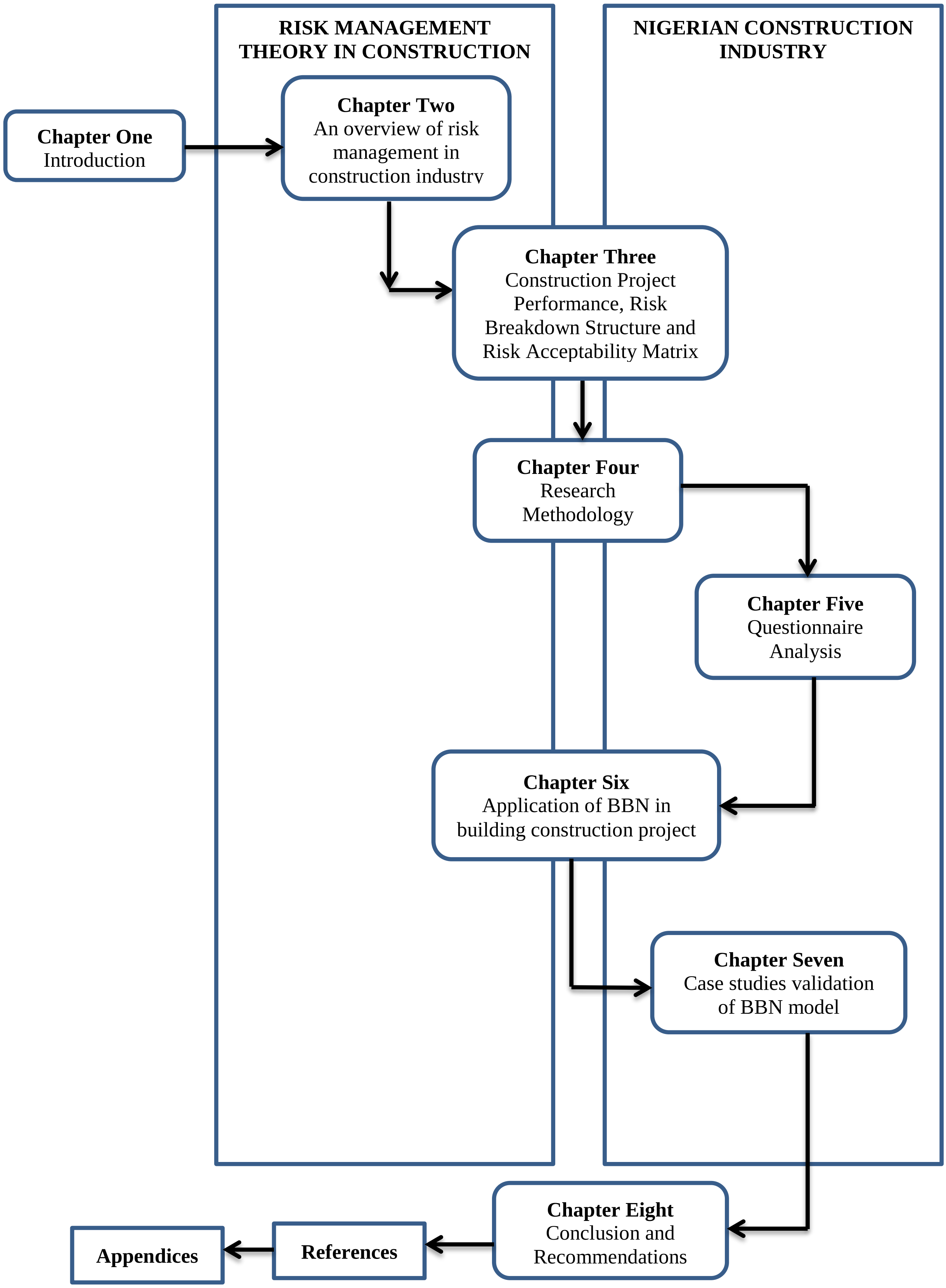


Figure 1.1: *Structure of the Thesis-Development of a Risk Management System for the Nigerian Building Construction*

CHAPTER TWO: CONSTRUCTION RISK MANAGEMENT

2.0 Introduction to Construction Risk Management

In order to provide an adequate background to serve as a historical connection between previous and current research, this chapter will present the theoretical structure of building construction in developing countries, core concept of risk management, risk definition and probability of occurrence, which emphasises a lot of the analytical approaches to risk. It also highlights the theory of risk and uncertainty with an explanation of their differences in a general sense and also reviews the extent to which the literature relates more directly to the objectives of this thesis. This chapter will also provide a critical overview of what a risk management process is.

2.1 Building Construction Industry in Developing Countries

Building construction projects which are associated with housing, offices, hospitals, factories, churches etc. are unique and built only once. Additionally, these construction projects are dynamic, as reported by (Bobick, 2000) and are characterised by many unique factors such as work team rotations, exposure to weather conditions and changes in topography, topology and working conditions throughout the project life cycle (Aneziris, Topali and Papazouglou, 2012). Figure 2.0 show how a typical building construction project is carried out in developing country.

Figure 2.0: Typical Building Construction Project in Nigeria

The term developing countries is described by the World Bank (2012) as countries with a Gross National Income (GNI) of US$11,905 or less per year. These countries have been listed by the International Statistical Institute (2015) (See appendix A). Developing countries constitute approximately 80% of the world population which can be categorised by lack of a high degree of industrialisation, infrastructure and other capital investment, sophisticated technology, widespread iliteracy and advanced living standards among their population as a whole (ASYCUDA, 2014). These countries represent about 20% of the global economies.

The case country Nigeria has a population of about 160 million people, which is the largest country in Africa and accounts for 47% of West Africa population (World Bank, 2015). The country is the largest economy in Africa with an estimated nominal GDP of US$ 510 billion (AEO, 2014).

The size of the Nigerian construction industry is estimated to be about £2.1billion (0.2%) which is very small compared to the global construction industry which is estimated to be about £2.6 trillion (Dantata, 2008). In 2012, the Nigerian building construction sector accounted for 1.33% GDP and this is below the world average benchmark for 9% of GDP (FMI, 2012). This result leaves a huge room for growth in the construction of buildings across all sectors of the economy in Nigeria. However, Buisson (2013), reports that Nigeria is the focus of a great deal of attention from the international infrastructure sector currently, as a result of infrastructure gap and the commitment of the government (federal and the state level to fill the gap) (Buisson, 2013).

The construction industry in a developing country like Nigeria can be categorised into two main groups as reported by Dantata (2008). This includes the organised and unorganised sector of the construction industry. The organised or sometimes called the formal sector of the construction industry constitutes of all legally registered companies in the country that carry out organised construction projects with a combination of highly skilled expatriates and labourers. It is however, evidenced that foreign construction companies dominate this construction market sector in developing countries most especially in Nigeria and most often, import equipment, materials and even labour (NELF, 2013). The sector operates under set rules and regulations, including adherence to national laws on employment, procurement, and tendering (Oladapo, 2015). On the other hand, the unorganised or informal sector of the construction industry for which no accurate or reliable data is available on, comprises simple residential building and similar structures built by private citizens and constructed through the effort of architects and labour, hired mainly using multiple prime method of construction like the owner supervised construction (Dantata, 2008).

However, an investment in building construction projects is, of course, not without risks. For many years, construction organisations in developing countries have approached risk management in building construction projects by using a set of practices that are normally insufficient, producing poor results most of the time, and limiting the success of project management (Serpell, Ferrada, Rubio and Arauzo, 2015). In recent times, construction works are still faced with problems of working capital, poor management and lack of good organization (Oladapo, 2015). These inefficiencies often give rise to disruption of work and loss of productivity, late completion of building projects, and third party claims and abandonment or termination of contract. The construction industry is not shaped to respond quickly to the needs of the clients which in most cases take far longer than expected and frequently fail to meet the target technical performance (Choughry and Iqbal, 2013). At the same time, distortions in prices and the shortage of materials and other inputs tend to cause allocative inefficiencies which make the works in hand economically more costly than they should be (The World Bank, 1984). In general, it can be said that risk management in developing countries is inadequate, lacks a systematic and formal approach, and its performance is not measured (Serpell et al, 2015). The inadequate growth of construction capacity most especially the capacity to manage construction risks in developing countries is a problem that both the public and private sectors need to face.

Since, risk management is an important area of project management, it allows anticipating the occurrence of events that could adversely affect a construction project and to define actions that could minimize their impacts. It is well known that one of the major roles undertaken by any project manager is to deal with contingencies or risks that occur continuously during the management of a project and this role is particularly complex and inefficient if risk management has not been performed or supported adequately from the start of the project (Serpell et al, 2015). For building construction projects which is vital to the economy of any nation, more so in a developing country like Nigeria, a risk management system will need to be in place to ensure swift closure of projects and to allow building construction projects to reach its potential.

Project managers must perceive risk management procedures as not only creation of previously unknown information, but also as information sharing, learning, knowledge and competence creation (Perminova, Gustafsson and Wikstrom, 2008). A properly implemented risk management process will enhance the successful completion of building construction projects and thereby making the project more profitable. At the same time, an efficient risk management system must be more dynamic in nature than the risk itself; otherwise, chances are that it may not integrate well into the organizational culture and other company practices (Choughry and Iqbal, 2013).

2.2 Construction Sector Risk

Risk is a complex phenomenon that has physical, monetary, cultural and social dimension (Loosemore et al, 2006). Risk entered the English Dictionary in the 17th century, coming from the French word risqué (Abujnah and Eaton, 2010). In the 18th century the word began to appear in insurance transactions (Flanagan and Norman, 2000). However, the word risk was a sailor's term that came from the Spanish, which meant to run into danger or to go against a rock (Jannadi and Almishari, 2003). Risk best qualifies the situation in which there are past records and experiences, and decisions are made under the prediction of what is the chance or probability of the outcome (Oztas and Okmen, 2004). According to Kartam and Kartam (2001), risk is the probability of occurrence of uncertain, unpredictable and even undesirable events that would change the prospects for the profitability on a given investment. Managing risk is to minimise, control and share risk and not merely passing them off unto another party (Kartam and Kartam, 2001). The Royal Society (1992) as cited in Edward and Bowen (1999) defines risk as the probability that an adverse event occurs during a stated period of time. Chapman (1997) defines risk as exposure to the possibility of economic and financial loss or gain, physical damage or injury, or delay as a consequence of the uncertainty associated with pursuing a particular course of action. Project in controlled environment (Prince 2, 2012) defines risk as the chance of exposure to the adverse consequences of future events. Consequently Smith et al. (2006) states that risk exists when a decision is expressed in terms of a range of possible outcomes and when known probabilities can be attached to the outcomes. Eaton (2003) defines construction risk as a potential event, either internal or external to a project that, if it occurs, may cause the project to fail to meet one or more of its objectives. Odeyinka, Oladapo and Akindele (2006) define construction risk as a variable in the process of construction whose occurrence results in uncertainty as to the final cost, duration and/or the quality of the project. Figure 2.1 provides a holistic view of project risk.

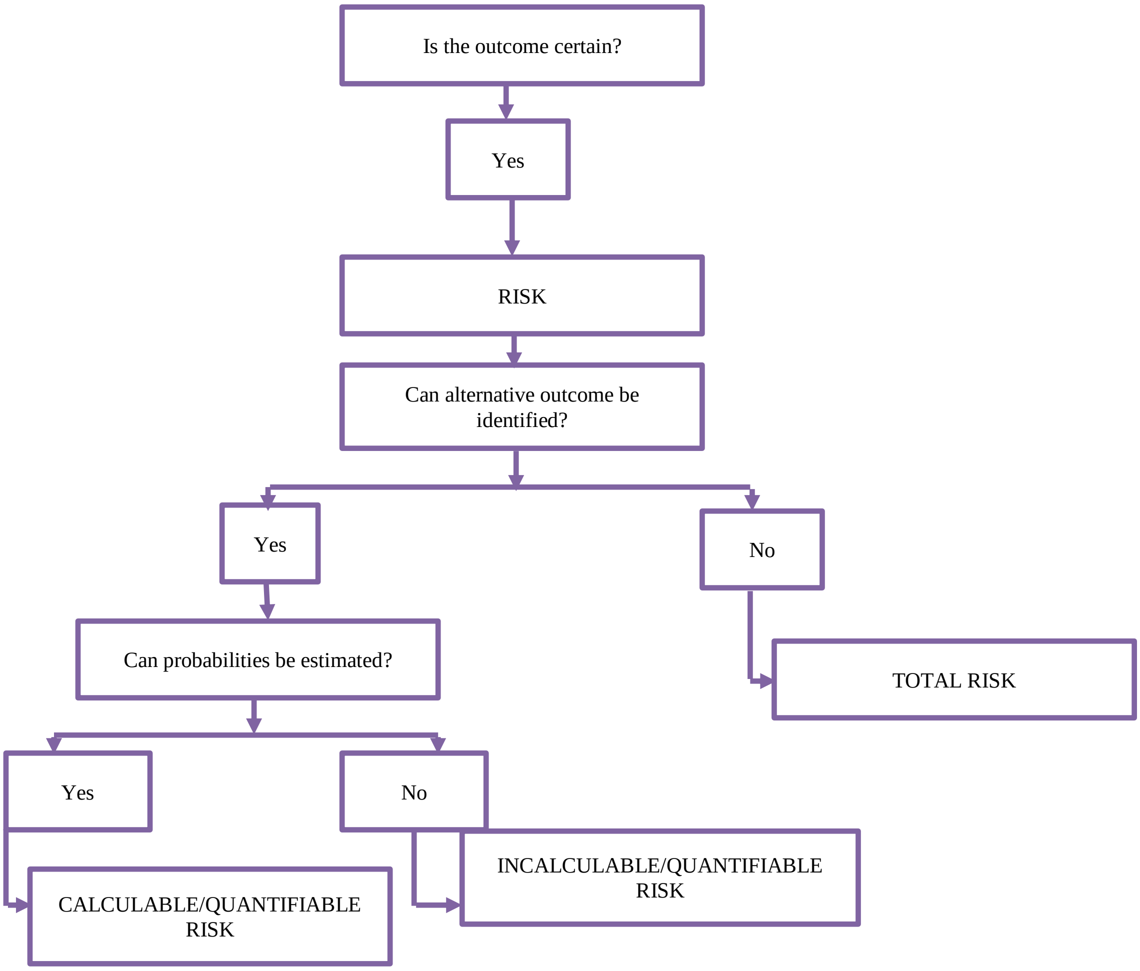


Figure 2.1 A Holistic View of Project Risk

Source: Bryde and Volm (2009)

From the definitions of risk, two common elements can be identified: uncertainty and loss. Hence, to discuss the presence of risk, there must be at least two possible outcomes; at least one of the possible outcomes must be undesirable. For example, if it is known that a loss will occur definitely, there cannot be any risk (Oztas and Okmen, 2004).

2.3 Construction Risk Management

Risk management is one of the ten project management areas (i.e., integration, scope, time, cost, quality, human resource, communications, risk, procurement and stakeholders) propagated by the Project Management Institute (PMBoK, 2013). Risk management is the culture, processes and structures that are directed towards realising potential opportunities whilst managing adverse effects (AS/NZS 4360, 2004), Zou et al (2007) define risk management in the construction project management context as a systematic way of identifying, analysing and dealing with risk as associated with a project with an aim to achieve the project objectives. According to the British standard 31100 (2011) risk management is the process whereby decisions are made to accept a known or assessed risk and/or the implementation of actions to reduce the consequences or probability of occurrence.

According to Smith et al (2006), clients, project owner (companies, organisation, etc.) have an overall risk management strategy and policy included in the strategic documents and quality management system. The project owners risk strategy are risk ownership (which party owns the risk; risk exposure and transfer) and risk financing (how to include and use budget risk allowance or contingency), client risk management policy includes the risk procedure or guidelines and reporting, clients and contractor are concerned with the magnitude and pattern of the investment and the associated risk (Smith et al, 2006). Risk management for construction projects according to Smith et al (2006) is illustrated in Figure 2.2.

Figure 2.2: Risk management strategy
Source: Smith et al (2006)

2.3.1 Risk Probability in Construction Projects

Probability is an important concept in dealing with risk, and its measurement has a long history. Definitions range from the classical deterministic notion that probability is the ratio of occurrence to the total number of equally likely causes to a much subjective or judgemental view (Abujnah and Eaton, 2010). For instance, in the tossing of a fair coin, the possible outcomes are generally predetermined, while in others, such as estimating construction cost will be more fuzzily determined (Abujnah and Eaton, 2010). In these latter cases, intuitive estimates may be as reliable as formal estimates; even intuitively our minds use probability to formulate our judgement (Flanagan and Norman, 2000).

Objective and Subjective Judgements can be used to determine the probability theory.

- Objective judgement- this believes that probabilities must relate to long-term frequencies of occurrence. In other words, only events that can be repeated over a large number of trials may be covered by probabilities (Flanagan and Norman, 2000).
- Subjective judgement- this shows that the probability of an event is the degree of confidence placed in its occurrence by the decision-makers on the basis of the evidence currently available. Subjective probabilities represent the degree of belief that a person is correct, based on the current information available (Flanagan and Norman, 2000).

2.3.2 Risk and Opportunity

According to Hillson (2002), the suggestion that a common process can be used to manage both threats and opportunities has arisen from the inclusion of positive aspects in recent definitions of 'risk'. This in turn has provoked vigorous debate among the community of risk practitioners, with individuals and groups taking and defending strong opposing positions. The issue is whether the term 'risk' should encompass both opportunities and threats, or whether 'risk' is exclusively negative with 'opportunity' being qualitatively distinct. Apparently, Hillson (2002) states that there appears to be two options:

- Risk is a canopy term, with two varieties:
  - "Opportunity" which is a risk with positive effects;
  - "Threat" which is a risk with negative effects.
- Uncertainty is the all-encompassing term, with two varieties
  - "Risk" referring exclusively to a threat, that is an uncertainty with negative effects;
  - "Opportunity" which is an uncertainty with positive effect.

However, Eaton (2010) describes risk as travelling in two directions.

- Upside risk- when the outcomes are good
- Downside risk - when the outcomes are bad

There is no doubt that common usage of the word 'risk' sees only the downside. Asking a person in the street if he would like to have a risk happen to him will nearly always result in a negative response "risk is bad for you". However, Dikmen and Birgonul (2006) report that when giving bid/no-bid decisions, decision makers usually try to assess the attractiveness of alternative projects by estimating expected opportunities as well as potential risks that will be retained by the company. Opportunities can be measured by expected performance of the project in satisfying the company objectives, whereas risk assessment requires identification of risk factors and quantification of risk impacts on project success. There report agrees with the most recent of the standards to include both opportunity and threat within the definition of ‘risk’ as described by the latest edition of the Guide to the Project Management Body of Knowledge (PMBoK) published by the Project Management Institute (PMI) in 2013, which states that “Project risk is an uncertain event or condition that, if it occurs, has a positive or a negative effect on a project objective”. Therefore, project risk includes both threats to the project’s objectives as well as opportunities to improve on those objectives.

It is argued by Hillson (2002) that opportunities and threats are not qualitatively different in nature, since both involve uncertainty which has the potential to affect project objectives. As a result, both can be handled by the same process, although some modifications may be required to the standard risk management approach in order to deal effectively with opportunities. However, the downside of risk will be the focus of this research especially for those affecting construction companies in developing countries.

2.3.3 Risk and Uncertainty in Construction Projects

The environment which decision-making takes place can be described in three methods, which include certainty, risk and uncertainty (Abujnah and Eaton, 2010). Certainty exists only when one can specify exactly what will happen during the period of time covered by the decision and conform to the specific requirements of certainty (Abujnah and Eaton, 2010). However, this does not happen in the construction industry.

The method of a systematic project management and organisation with special emphasis on effective planning, communication and evaluation to achieve desired outcomes is still very dominant (Alderman et al, 2005, Maylor, 2003 and Wikstrom 2005). As a result, the traditional view on project risk management (as well as project management in the whole), stresses the importance of planning as one of the major routines, supporting other activities such as risk identification, analysis, monitoring and control (Perminove et al, 2008).

Uncertainty is inherent in projects and refers to elements that change over time and are hard to predict and control (Osipova and Eriksson, 2013). Project risk originates from the uncertainty that is present to a different extent in all projects (Perminove et al, 2008). The project management book of knowledge (PMBOK, 2000) defines project risk as an uncertain event or condition that, if it occurs, has a positive or a negative effect on at least one project objective, such as time, cost, scope, or quality. The causes or condition of risk, according to the same source, arise from the project or organization's environment, such as on-going multiple project, poor management practices, dependency on external participant etc. Consequently, PMBOK (2000) describes risk through the notion of uncertainty but does not specify what uncertainty is. Making a distinction between uncertainty and risk is necessary in order to be able to explain the influence of these on project performance (Perminove et al, 2008). According to Perminove et al (2008), uncertainty is a context for risks as an event having a negative impact on the project outcomes, or opportunities, as an event that have beneficial impact on project performance. This definition stresses dual nature of uncertainty in potentially having both positive and negative influence on the project's outcomes.

Uncertainty can arise from sources both internal and external to the project. However, Atkinson et al (2006) give an insightful identification on the sources of project risk. In their report, they identified three sources of project uncertainty. These are;

I. Uncertainty in project estimates originates from incomplete and inaccurate data and lack of a structural approach to deal with missing information. This uncertainty results in erroneous estimations in cost, time and quality.
II. Uncertainty in project organization emerges from the fact that different actors work together and thereby causing problems of opportunistic behaviour and risk allocation.
III. Uncertainty associated with the project life-cycle is generated throughout the project and is related to inputs and outputs of each phase and the interactions among them.

Arunraj et al (2013), reported that the equation used for risk arising from the occurrence of an undesired event is

$$R = P\,(Uci) \times M\,(Uci) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

Where P (Uci) represents the probability of an undesirable consequence and M (Uci) is the magnitude of the loss.

Consequently, Perminove et al. (2008) describe uncertainty, in contrast, as an event or a situation, which was not expected to happen, regardless of whether it could have been possible to consider it in advance. In other words, uncertainty is when the established facts are questioned and thereby the basis for calculating risks (known negative events) or opportunities (known positive events) is questioned. Therefore, a construction organization can operate in a complex environment where events are uncertain. The scope of uncertainty in any building construction project is considerable and most project management activities are concerned with managing uncertainty in projects from the conceptual design up to the maintenance phase of the project life cycle by clarifying what can be done, deciding what is to be done, and ensuring it gets done (Ward and Chapman, 2003).

2.3.4 Managing Uncertainty in Construction Projects

Uncertainty in construction projects cannot be managed by similar means as risks or certainties. Certainly, traditional project risk management processes such as planning, monitoring and control are effective for avoiding risks. There is a gap between traditional project risk management tools such as planning and risk analysis, which aim to take hold off the future, and monitoring and control, which reflects the history (Nikander and Eloranta, 2001).

However, managing uncertainty is more than just the combination of risk management and opportunity management, it is about identifying and managing all the sources of uncertainty which gives rise and shape the perceptions of threats and opportunities, in other words it is exploring and understanding the origins of project uncertainty before seeking to manage it, with no preconceptions about what is desirable or undesirable (Chapman and Ward, 2003). Since project management is a life cycle, its practical application shows that procedures related to forecasting the future are not repeated at each and every stage of the project (Perminove et al, 2008). Control as a source of historical data confirms that the problem has already taken place and cannot be any longer removed with the help of precautionary methods because the project is a time bound process (Nikander and Eloranta, 2001). Building construction project and its environment are in continuous process of change, which emphasizes the importance of reflecting as means of identifying potential dangers and opportunities, so that the choice between alternative activities can be made as fast as possible (Perminove et al, 2008). This leads to the fact that project organizations lose their flexibility in responding to different situations.

Furthermore, project managers perceive risk management procedures as not only as creation of previously unknown information, but also as information sharing, learning, knowledge and competence creation (Perminove et al, 2008). Thereby it can be concluded that development of project management skills is an essential part of understanding and managing uncertainty (Perminove et al, 2008).

Consequently, according to Perminove et al (2008), not all the elements in project environment or organization are critical to the project success and represent sources of uncertainty. That is why identifying relevant ones from the contextual uncertainty by means of environmental scanning or other analytical models is an important part of project management (Nikander, and Eloranta, 2001). Judging the source and relevance of information that comes from the outer project environment and, thus, represent contextual uncertainty is an intuitive process rather than a rational one, since the rational processes are isolated from the surrounding world (Wikstrom and Gustafsson, 2005). Therefore, intuitive processes are goal-oriented and reflective. As a result, understanding objectives and purposes of key actors, on who project success is dependent, as well as developing communication and coordination between the parties involved is of crucial importance (Perminova et al 2008). Such actions can be considered as part of project organizations strategy implementation and organization’s competitive advantage supporting customer centred thinking and facilitating the ability to provide high-value integrated solutions. This is a way of establishing certainty for the project team. Uncertainty becomes either risk or opportunity, which are certain by our definition. It must be mentioned, that uncertainty cannot be eliminated completely. Still, continuous reflective learning and information sharing make it manageable by reducing it significantly (Perminove et al, 2008).

2.4 Benefits of Construction Risk Management

A properly implemented risk management process will enhance the successful completion of building construction projects and thereby make the project more profitable. Key advantages of risk management process as described by Toader el al. (2010) and Poh (2005) are;

- It is efficient: project managers are aware about the risks which influence the activity of the project and manage them so that they do not occur
- The application of risk analysis in the tendering stage enables a realistic project pricing.
- Efficient risk management increases the chances of success of the project, despite the uncertainties, which exist in the project environment.
- In the presence of risk information, more comprehensive and accurate decisions about risks can be made
- The availability of risk knowledge will prove to be valuable information for planning and risk information in the future. The mistakes made in the past projects could be avoided
- The good track record and proven risk management systems of construction firms will enhance their chances to secure future projects from the same project owner
- The risk management process can improve communication among project participant.

A perceived summary of the benefits associated with an effective risk management process is shown in Figure 2.3.

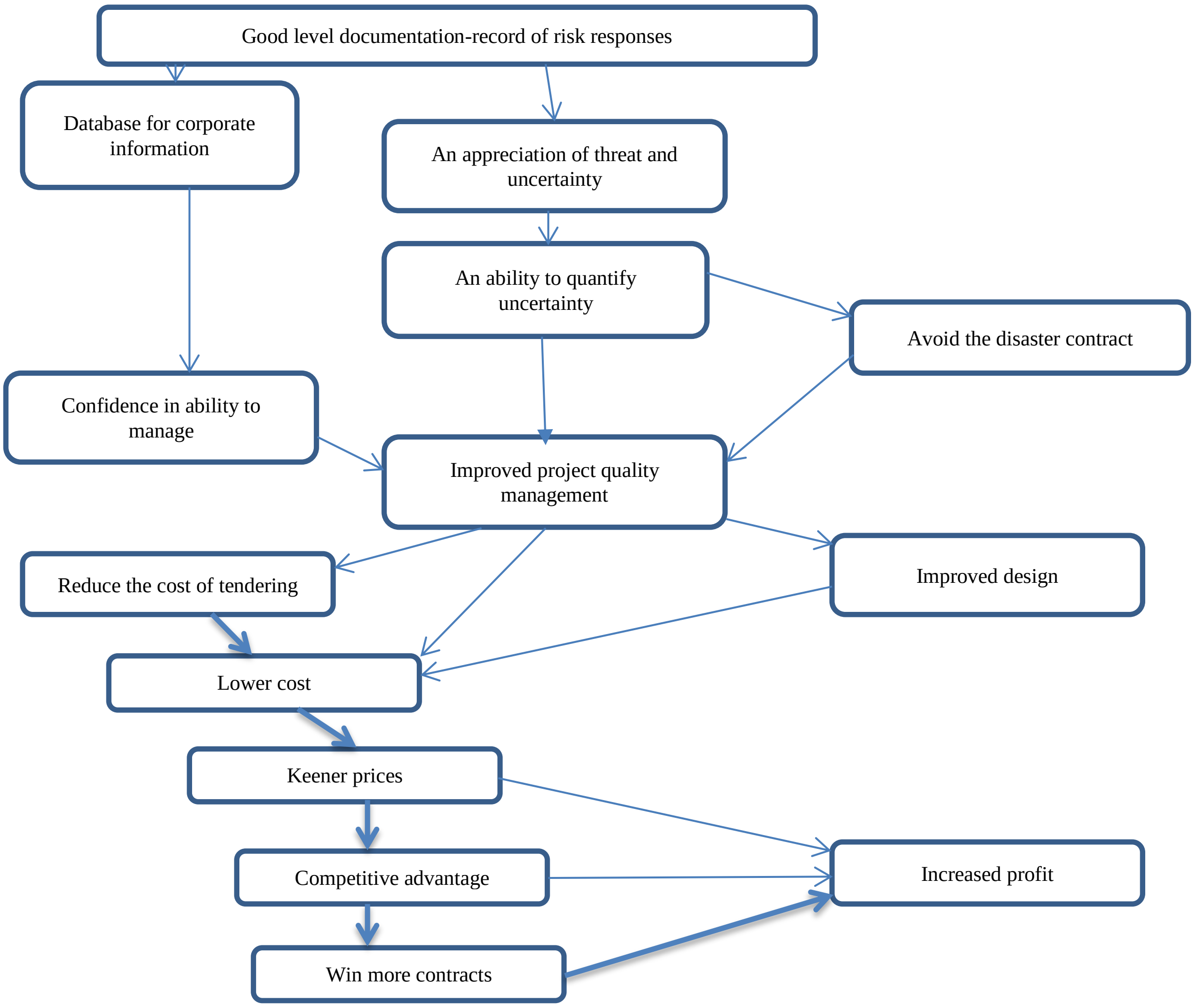


Figure 2.3: Benefits of a risk management process.
Source: Chapman (1997).

2.5 Risk Management Process for Construction Projects

Risk management is a cyclical process, which is made up of critical steps. A number of risk management processes have been proposed. Risk management is the effort to optimize decisions in order to reduce uncertainty about future events when the information is incomplete, unclear or under discussion (Jafari, Rezaeenour, Mazdeh and Hooshmandi, 2011). Early studies on risk management had outlined different approaches to risk management. For example, Chapman and Ward (1997) outlined a generic project risk management process consisting of nine phases:

- Define the key aspects of the project
- Focus on a strategic approach to risk management
- Identify where risks might arise
- Structure the information about risk assumptions and relationships

- Assign ownership of risks and responses
- Estimate the extent of uncertainty
- Evaluate the relative magnitude of the various risks
- Plan responses and
- Manage by monitoring and controlling execution.

Akintola and Macleod (1997) also suggested a process that consists of; identification, analysis, assessment and control. However, the construction industry recognizes that a systematic risk management is essential to manage the risks affecting construction projects. Jafari et al (2011) states there are four well-known approaches to risk management which have been propagated by the following institutes. These are; PMBOK (2004), Project Risk Analysis and Management (PRAM) (APM, 2004), Management of Risk (MOR) (Office of Government Commerce, 2007) and the standard AS/NZS4360:2004 (Standard Australia/standards New Zealand, 2007), however, there is no significant difference between them. The key steps of planning, identification, qualitative and quantitative analysis, reaction to risk, and controlling are present in all these approaches. According to Jia, Ni, Chen, Hong, Chen, Yang and Lin (2013), Figure 2.4 illustrates six processes and their relationships. Among these processes, risk management planning is the starting point of the entire risk management procedure; it is generally useful to regulate and promote four successive processes in the core risk management cycle to roll forward with management system oriented self-improvement in the whole project development flow from project inception through design and construction to project completion. Risk management reporting is the finishing point of the entire risk management procedure. It is generally useful to summarize the risk management with regular outputs with regard to predefined risk control points, and helps organizations to understand current situations and take corresponding measures in their risk management practice.

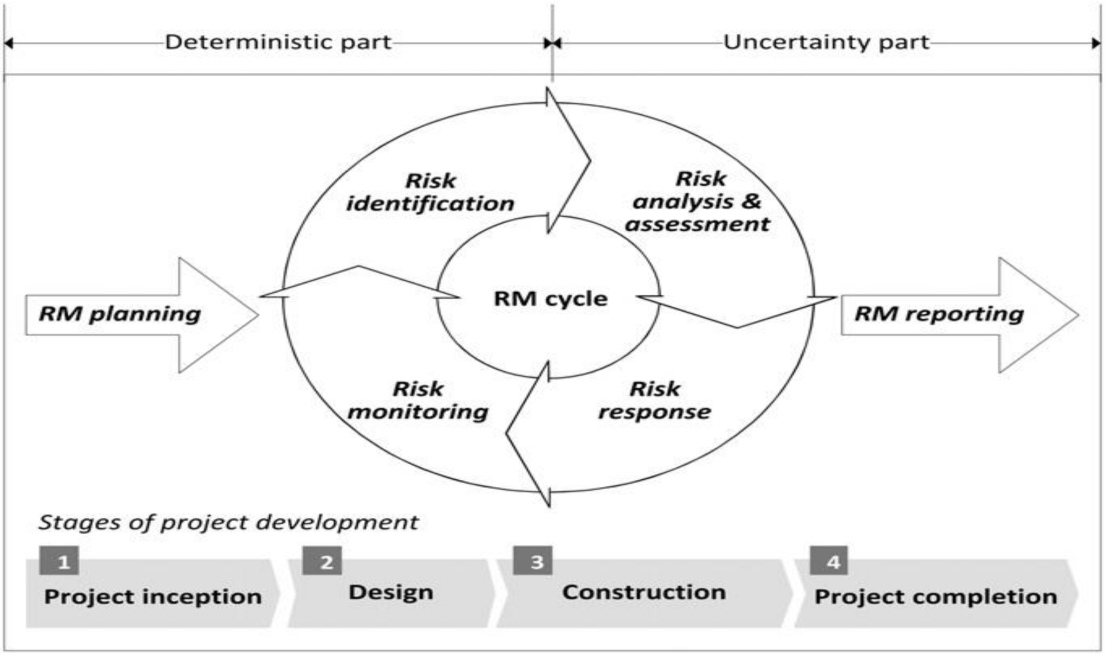


Figure 2. 4: Risk management process for construction projects
Source: Jia et al (2013)

Accordingly, this cyclical risk management process also agree with the definitions of construction –related professional institutions such as, the Association of Project Management (APM, 2004), Institution of Civil Engineers (ICE, 2015) and the Construction Industry Research and Information Association (CIRIA, 5015). These construction institutions recognize that a structured and systematic risk management is essential to manage the risk affecting construction projects.

2.5.1 Definition of Risk Management Objective

The first stage of the risk management process clearly defines the objectives of the risk identification and assessment process. This stage is important because it shows the scope and margin for the extensive risk identification and assessment procedures (Issac, 1995).

2.5.2 Risk Identification

According to Tchankova (2002), the process of risk management begins with risk identification which develops the basis for the next steps of analysis, assessment and control. If this is done correctly it ensures risk management effectiveness. Consequently, it illustrates that risk identification must be seen in a broader way and not just be seen as what can be insured or mitigated (Tchankova, 2002). It should start with the basic question of;

- How can the project resources be threatened?
- What adverse effect can prevent the project from achieving its goals?
- What favourable possibility can be revealed?

The identification process at start enables a good basis for the implementation of the project and does not put up any barrier about the type of risk that would be identified or the resources that can be influenced (Tchankova, 2002). Risk identification reveals and determines the possible project risk as well as conditions (Williams et al, 1998). Risk identification enables the project managers to study activities and places where resources are exposed to risk. According Tchankova (2002), risk identification can be described based on these elements;

- Sources of risk: these are the elements of the project environment that can bring some positive or negative outcome.
- Hazard: it is a condition or a circumstance that increases the chances of losses or gains and their severity.
- Peril: this is a circumstance that is close to risk and has negative, non-profitable results. Peril can happen at any time and cause unknown, predictable losses. Peril is the cause of losses.
- Exposure to risk: this is an object facing possible loss or gain. They will be affected if the risk occurs.

Risk identification is a continuous process. It is not possible to identify risk as a one off activity (Tchankova, 2002). Practically, the techniques used to thoroughly capture the critical risks affecting a building construction project include but is not limited to;

I. ***Brainstorming***: This is the commonly used method (APM, 2004). The technique involves bringing together all interested and relevant parties or personnel to identify and assess risk in a building construction project. This purpose is to generate a large quantity of potential risks affecting a project. Consequently, this process encourages the identification of risk concerns in a non-critical way and not ascribing blame to the identified risk (Banes, 2000). In order to gain an effective brainstorming session, it must include individuals of knowledge, experience and expertise in risk management with an optimum size of twelve members (Chapman, 1997; Smith and Bohn, 1999).

II. ***The Delphi Technique***: This process involves a process where qualified people are consulted and asked to identify risks or estimate the impact and probability of previously identified specific risks through questionnaires. Opinions are given anonymously (this allows the technique to be carried out remotely). The risk co-ordinator summarises the responses and elicits estimates based on the results. This information is re-circulated for a repeat session. The process will continue until a stable opinion is reached (Banes, 2000). This technique is more time consuming and expensive compared to the brainstorming technique (Chapman 1998). An added shortage of this technique is the lack of interaction and communication, the respondents may encounter difficulties in interpreting the questions and results.

III. ***Interviews***: Interviews may be used as a follow-up to the group-oriented techniques previously described. Individuals with expertise relevant to a particular risk issue may be interviewed to assess risk parameters, identify possible mitigation and contingency measures and to elicit data. This is a precursor to any quantitative analysis that maybe required (Banes, 2000). This technique is time consuming. Due to time limitations, the questions must be properly structured in order to effectively gather the required information. Vague and confusing questions should be avoided so that the feedback gained from the interviewees is not misleading (Chapman, 2001). Another concern about this technique is that the information acquired is based on expert' subjective judgement which may not be free from bias.

IV. ***Experiential knowledge:*** this is a process where individuals obtain information through their experience in the construction industry (Clear Risk, 2015). It is important to note that in this kind of process, knowledge based information acquired must be relevant and applicable to the existing building construction project.

V. ***Outputs from Risk-oriented Analysis:*** According to Clear Risk report (2015), there are various types of risk oriented analysis. Examples are the fault tree analysis and event tree analysis. These approaches are top down analysis approach that intends to determine what event, conditions or faults that could lead to an undesirable or unacceptable event. These events can be associated to a risk in a construction project.

VI. ***Risk Register***: Risk register contains a standard format in which to record risk information gathered using the risk identification techniques previously described. It records various data for each individual risk issue, including a description, potential causes, ownership, probability, impacts, mitigation and fall-back plans and status (Banes, 2000). In its detailed form it may even include an identification of secondary risks, contingency plans and quantitative parameters (Banes, 2000). Nevertheless, the use of checklists to initiate the risk identification process is not advisable since they may constrain the identification of new risks (ICE et al., 2005).

2.5.2.1 Sources of Construction Risks

A direct relationship between effective risk management and project success is acknowledged since risks are assessed by their potential impact on the project objectives (Balio and price, 2003). Therefore, engaging effective risk management techniques to manage risk associated with variable construction activities has never been more important for the successful delivery of projects (Zou et al. 2007).

Different definitions and classifications can be used in managerial practice. Tchankova (2002), reports that general classification may use physical, social and economic sources. However, an in-depth investigation of the problem of risk identification may need classification that can cover all types of risk in more detail (Tchankova, 2002). Hence, the sources of risk can be represented depending on the construction environment.

Many approaches have been suggested in literatures for classifying risk. El- Sayegh (2008) presented a list of several factors in the terms of owners, design, contractors, sub-contractors, suppliers, political, social and cultural, economic, natural. Nieto-Morote and Ruz-Vila (2011) suggested four ways of classifying risk: project management, engineering, execution and supplier's risk. Kuo and Lu (2012) group risk into five sub-sets: engineering design, construction management; construction safety-related, natural hazards, socio and economic while Dikmen et al (2007) categorised risk into eight ways: technical, managerial, resource, productivity, design, payment, client and subcontractors' risk. Many ways can be used to classify the risks associated with construction projects and the rationale for choosing a method must serve the purpose of the research.

2.5.3 Qualitative Risk Analysis

Qualitative risk analysis is regarded as the most useful part of the risk management process as the results gained from the analysis will be used extensively in the subsequent stages (Smith, 1999). Important information about risks such as the likelihood of occurrence, the risk severity, and risk ownership is required at this stage. Risks are often qualitatively assessed using Probability-Impact (P-I) Grids.

I. **Probability-Impact (P-I) Grids** - are a tabular format for assessing and ranking risks. Two attributes of: probability of occurrence; and risk impact; form the rows and columns of the grid as seen in Table. 2.1. The advantage of using probability-impact grids is their simplicity, and risks can be assessed conveniently without precisely specifying their impacts and probabilities of occurrence (Ward, 1999).

Table 2. 1: Example of a P-I table
Source: Vose (2008)

Impact	V High					
	High					
	Med					
	Low					
	V Low					
		V Low	Low	Med	High	V High
		Probability				

For each risk characteristics, the estimates of likelihood of events and consequence of events can be assigned qualitatively, for example: High; Medium; and Low etc. as shown in Table 2.1; and each of these verbal scales can be related to a scale value. The P-I score for each cell in the grid can be determined as the result of the multiplication of probability and impact scale values; an arbitrary value; or an alphabet (Ward, 1999). Consequently, it is necessary to achieve a consistent quantification of risk likelihood of occurrence and the magnitude of the risk by using a common language in describing them as been suggested by Tah and Carr (2001).

2.5.3.1 Risk Exposure

Fraser and Simkins (2010), describes risk exposures as the extent to which one is exposed to risk (or a portfolio of risks). It is a function of the potential impact of a risk event and its probability of occurrence. These potential risk events however can impact on a construction organization in achieving its goals (Fraser and Simkins, 2010). Consequently, if more than two events may occur, risk exposure is used to quantify and compare and decide how to respond to them.

Lock (2013), demonstrates the use of four main quadrants for risk exposure which are:

- High chance – High impact
- High chance - Low impact
- Low chance – High impact
- Low chance – Low impact

The least important type of risk is the low chance-low impact, and the most important type of risk is the high chance-high impact. Consequently while describing risk assessed qualitatively to determine their likelihood and potential effect on project objectives, Hillson (2002) reports that the Probability–Impact Matrix is useful, involving rotating the opportunity half as shown in Figure 2.5 This allows key threats and opportunities to be visualised by focusing on the so-called *''Arrow of Attention''*. The size of this wedge can be increased if the organisation is more risk-adverse or if more effort is available for risk management.

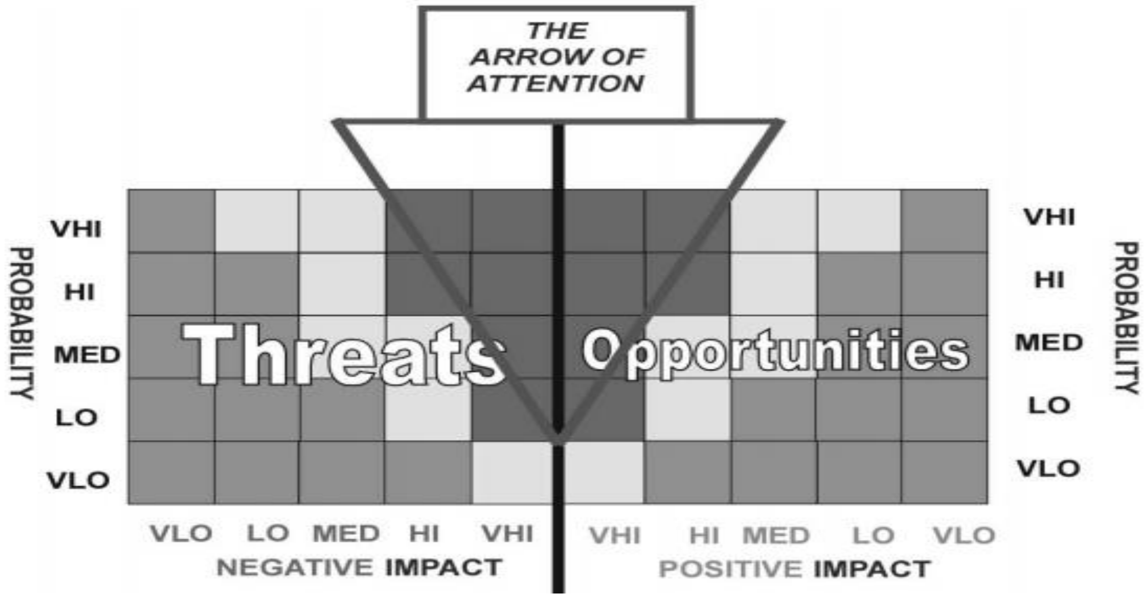


Figure 2.5: Probability-Impact Matrix for opportunities and threats
Source; Hillson (2002)

From Figure 2.5, the probability and impacts of each risk are assessed against defined scales, and plotted on a two-dimensional grid. Position on the matrix represents the relative significance of the risk, and high/ medium/low zones may be defined, allowing risks to be ranked.

2.5.3.2 Risk Acceptability

Depending on the amount of risks an organization might be facing, individual risk can be classified as unacceptable (intolerable must be eliminated or transferred), undesirable (To be avoided if reasonably practical, detailed investigation of cost justification is required, top level approval is needed, monitoring is essential), acceptable (can be accepted provided that the risk is managed) and negligible (No further consideration needed) as suggested by Godfrey (1996).

2.5.4 Quantitative Risk Analysis

This process is made easier with the creation of a model, which represents the project being studied (Banes, 2000). The model may then be modified to quantify impacts on the project of the specific risks identified using qualitative techniques (Banes, 2000). It also explains the effect of general uncertainty on the project (Banes, 2000). The model may be constructed based on an activity network, spread sheet, or a diagrammatic tool. Whichever modelling method is used, it will include all those elements comprising the undertaking (tasks, costs, durations etc.), which are relevant to the risk analysis (Eaton, 2010). Against these elements, uncertainty variables can be entered rather than deterministic values, in order to reflect areas of significant uncertainty (Eaton, 2010). A range of techniques for quantifying risk has been recognized but for the purpose of this study, the following are examined as they contain valuable logic that may lead to explaining and reasoning as part of a quantitative model.

I. **Decision trees**: A decision tree is a graphical method of modelling a project, showing the possible effects of individual risks requiring project decisions and immediate-planned courses of action to the overall outcome (Eaton, 2010). Each outcome is assigned a probability of occurrence allowing the most probable outcome to be determined. Alternative actions can be explored within the model in order to identify the most beneficial expected outcome of the project or activity (Banes, 2000).

II. **Influence Diagrams**: The influence diagram was first defined as an aid to formulating problems prior to decision-making (Banes, 2000). Influence diagrams allow the construction of models representing the influences upon a project goal or target. The model exposes the key influences and allows the effect of uncertainty to be determined. These models can become very complex, leading to the need for effective graphical presentation as well as computational efficiency (PRAM, 2004).

III. **Probabilistic Analysis**: This is a statistical method, which calculates the impact of every single risk factor, or the impacts of all risk factors on the project (Boothroyd and Emmett, 1996). In this technique, Optimistic, Most Probable, and Pessimistic time and cost estimates are given for each activity, or for the project as whole (Eaton, 2010).

IV. **Sensitivity Analysis**: this technique seeks to examine the sensitivity of a risk model to individual risk (Banes, 2000). This is done by repetitive calculation of the effect on the project outcome of a range of values of the variables. The project outcome is usually considered in terms of time of construction, or the final cost of a project (Eaton, 2010).

V. **Monte Carlo Simulation**: this is a technique where single value estimates (of duration, resource, cost, and logic) are replaced by a distribution to reflect the perceived uncertainty of those estimates (Banes, 2000). A random number is then generated and a corresponding value sampled from the distribution. Once samples have been taken from all variables in the model, a single value is calculated for each target (e. g. time and cost overruns). The process is repeated a large number of times (iterations) to give a distribution of possible outcomes (a simulation).

VI. **Simple Assessment**: This is a relatively simple mathematical method that investigates the significant risks separately by inspecting their probable effect on total project time/cost (Boothroyd and Emmett, 1996). The evaluation is based on calculating the expected impact of every significant risk. The impacts are added up and the total impact is used as foundation for a contingency plan.

VII. **Criticality Analysis**: Traditionally in project planning, the duration of each project task is given a single point estimate (the most likely value) and an analysis is performed to determine the critical path that is the tasks that directly determine the duration of the project. Criticality analysis allows the project manager to determine which activities could become critical if risks are not being effectively managed, and also indicates the subcritical paths which could be monitored alongside the main project critical path. Particular attention should be paid to tasks with a high criticality index, especially if they also have significant risks associated with them (Banes, 2000).

In the quantitative risk analysis phase, Sodhi and Tang (2012), identified expected outcomes for risk analysis in construction risk so that they can be used to define the expectations to be supported by risk model as to:

- Understand the nature of threats and other risks to help counter these better
- Support risk measures for informing their stakeholders,
- Help management focus on specific areas and
- Support allocation of risk management efforts and budget to different risk mitigations such as to answer the question of who should make such an investment (contractors, subcontractors or its clients) in construction industries.

The selected model should be able to provide the outcomes which can fulfil the defined purposes of the building construction risk analysis.

2.5.5 Risk Response and Monitoring

After risks are identified and analysed, they are not left unattended in the implementation phase of construction projects. The outcome of risk analysis enables responsible parties to understand the risk impacts, and subsequently plan and undertake effective risk mitigation actions to curb the effect before or when they occur.

Some organisations prepare to cope with uncertainty by different strategies and this can affect the building construction process system. How much the effects of adverse events can disrupt the building project performance depends on how well the current mitigating actions are implemented. The interaction of risk mitigating policies for different aspects has also been shown through the concept of risk-reward relationship (e.g. Chopra and Sodhi, 2004). The understanding of possible risk mitigating actions should thus be defined as a key concept for systemic risk modellers. General risk mitigating actions have been clearly explained by Vose (2008) especially in terms of implementing different risk mitigating strategies in different situations (Figure 2.6).

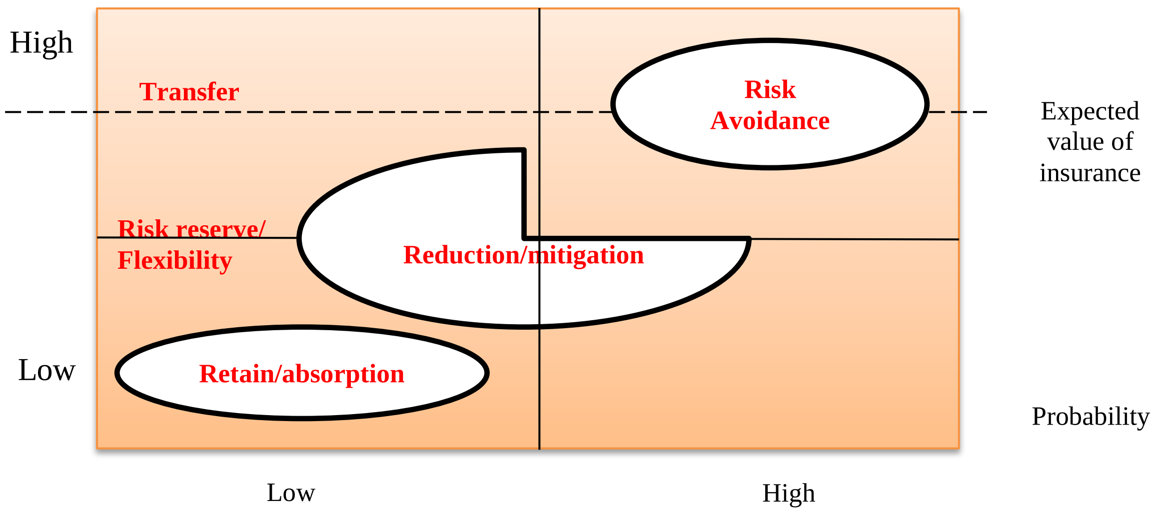


Figure 2.6 Mapping risk mitigation strategies with levels of probability and consequence
Source: Vose (2008)

According to Vose (2008) the responses for threats are:

1. Risk avoidance changing some aspect of the project so that the threat either cannot have an impact anymore or can no longer happen.
2. Risk transfer is another form of "reduce" response for reducing the impact only, and it is mostly only the financial impacts (a third party takes this responsibility). Common practice in risk transfer is to sign contracts that guarantee a certain level of performance and set penalties for when the contractor fails to meet it. Insurance is an attractive option when the adverse event that will happen is above the expected cost of insurance.
3. Risk reduction is a proactive action taken to either reduce the probability of the event occurring or to reduce the impact of it. However, this needs to be done at the strategic level because relevant high level of cost is involved. This option is suitable for any level of risk that is not severe (high probability and high impact) by trading off between benefits and costs.
4. Risk reserve/flexibility aims to increase responsiveness by adding some reserve (buffer) to cover risks or using redundancy policy. This risk reserved option is suitable for small or medium impact risks.
5. Risk retention/absorption/acceptance can be called self-insurance, because some risks are not critical so the cost of insuring against those risks may be higher than the cost of the loss if the adverse event happens. In other words, it is a conscious decision taken for retaining the threats. This option is suitable for risks that are not significant because they have both low likelihood and impact, compared with the cost of control.

And the responses for opportunities are:

1. Exploit: Grasping an opportunity to make sure it will happen and its impact will be realized.
2. Enhance: A proactive action taken to enhance the probability of the event occurring or to enhance the impact of it.
3. Reject: A deliberate decision taken for not exploiting or enhancing the opportunity.
4. Share: Parties sharing the gain (within pre-agreed limits), normally when the cost is less than the cost plan.

In practice, decision maker may be satisfied with their current level of risk with respect to the risk-reward trade-off. In other words some decision makers may think that they have spent too much on resources (money, time, etc.) for managing risks which may not necessarily happen, so they may want to reduce their level of risk protection (Vose, 2008). However, this option can lower the public credibility of the construction organisation, which may adversely affect the organisation's reputation and image. Another option is gathering more data to reduce uncertainties of unknown (epistemic uncertainties) in order to make a robust decision (Ellegaard, 2008; Vose, 2008). Besides the direct strategy to manage risks, knowledge creation is useful as it can help to reduce either probability or the effects of risk effectively (see more discussion in Ellegaard, 2008).

2.6 Risk Management Frameworks in the Construction Industry

The following construction professional institutions, the Institution of Civil Engineers (ICE), the Association of Project Management (APM), and the Construction Industry Research and Information Association (CIRIA) in recent years have separately taken initiatives to develop frameworks for the systematic project risk management. Their goals are to provide the construction industry with a structured, practical and easy to follow approach to the handling of risk and most importantly to promote the general use of a systematic approach to manage risk more effectively.

The risk management framework developed by CIRIA (1996) in figure 2.7, shows the implementation of a risk management process and the available methods for each step is described in detail, though there is relatively less coverage of the quantitative aspect in the process. The importance of the risk register in risk identification and assessment is stressed.

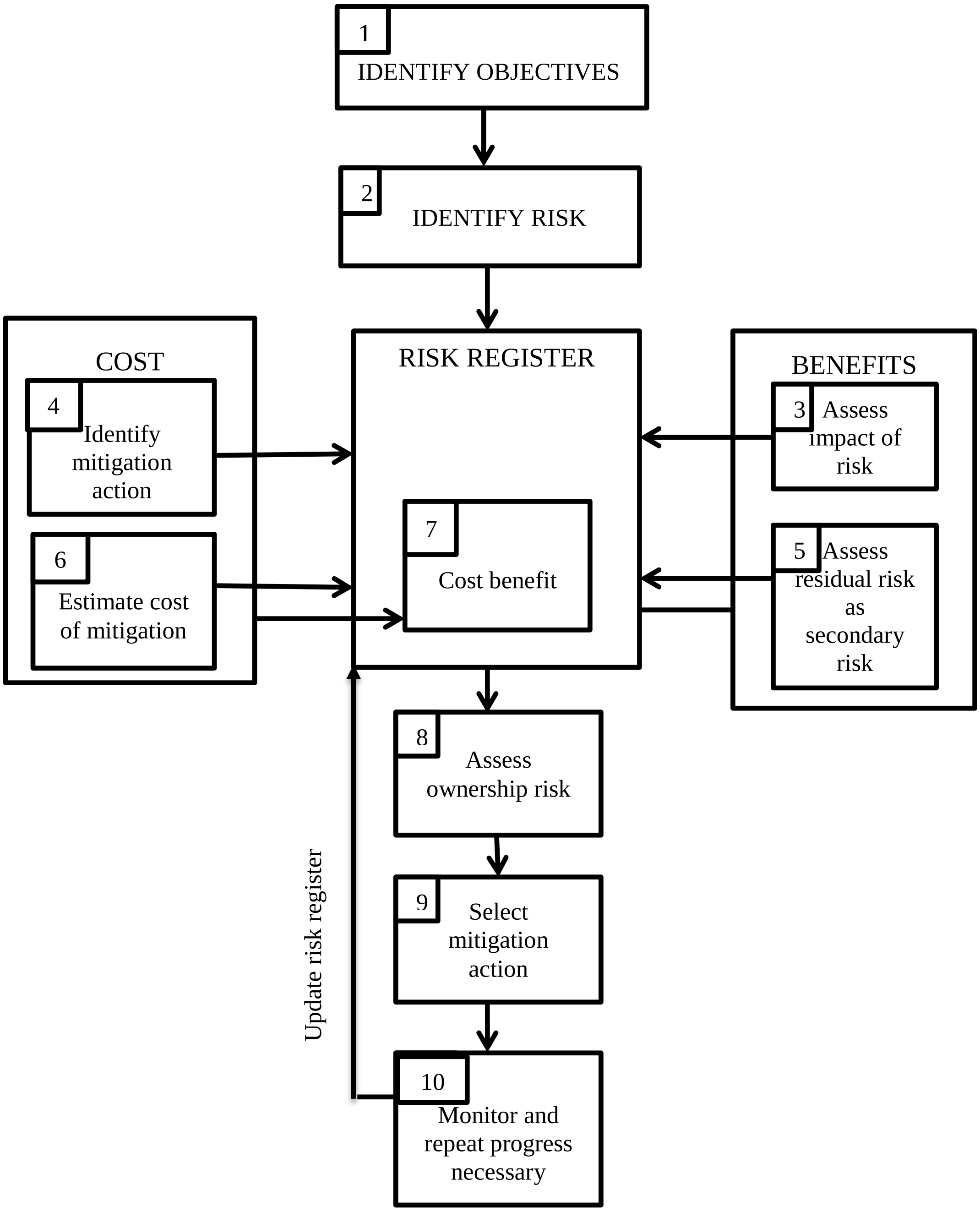


Figure 2.7: Flowchart of CIRIA risk management process

Source: CIRIA (1996 cited in Abujnah, 2010)

Apart from concentrating on the phases of the Risk Management Process, the Project Risk Analysis and Management Guide (PRAM) proposed by APM (2004) in Figure 2.8 has a more balanced coverage of both the qualitative and quantitative risk analysis process. However, the quantitative techniques provided are largely based on statistical and probabilistic approaches.

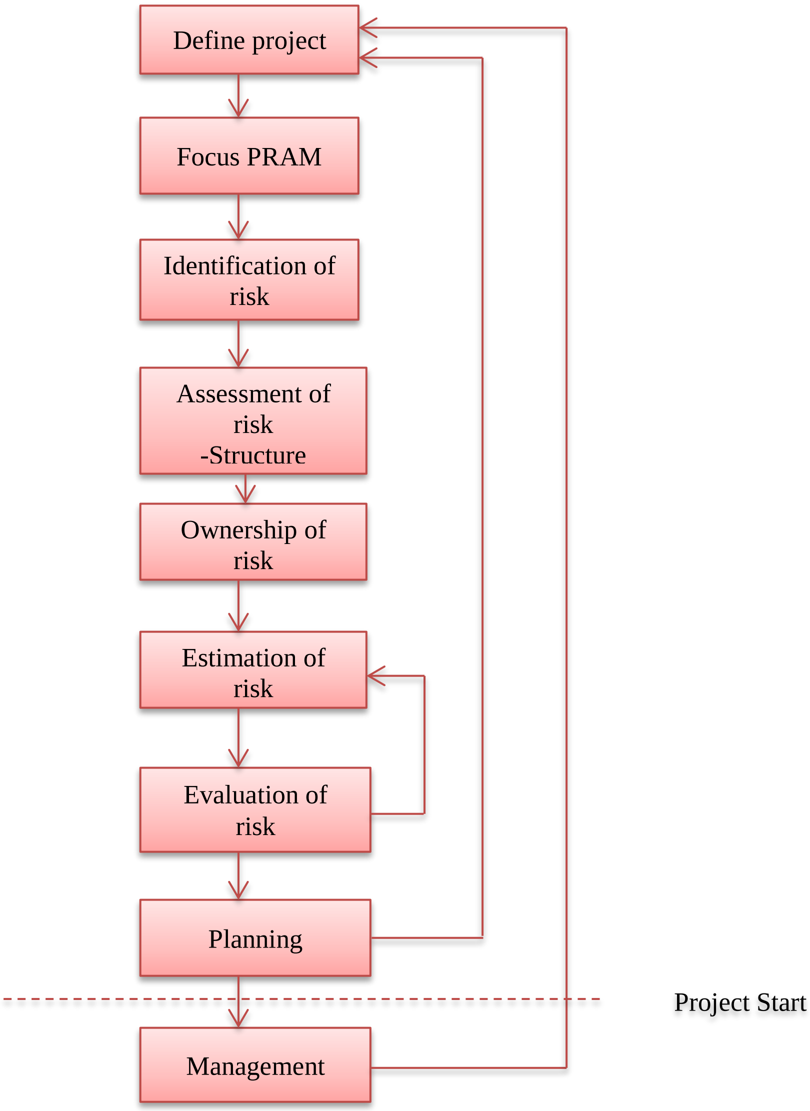


Figure 2.8: Flowchart of PRAM risk management process

Source: APM (2004)

Risk Analysis and Management for Project (RAMP) shown in Figure 2.9 is a framework developed by ICE et al (2005). It defines projects in a wider context covering both project construction and operation phases. It concentrates on the strategic aspect of risk appraisal and management, and it recommends users to refer to PRAM for the quantitative techniques.

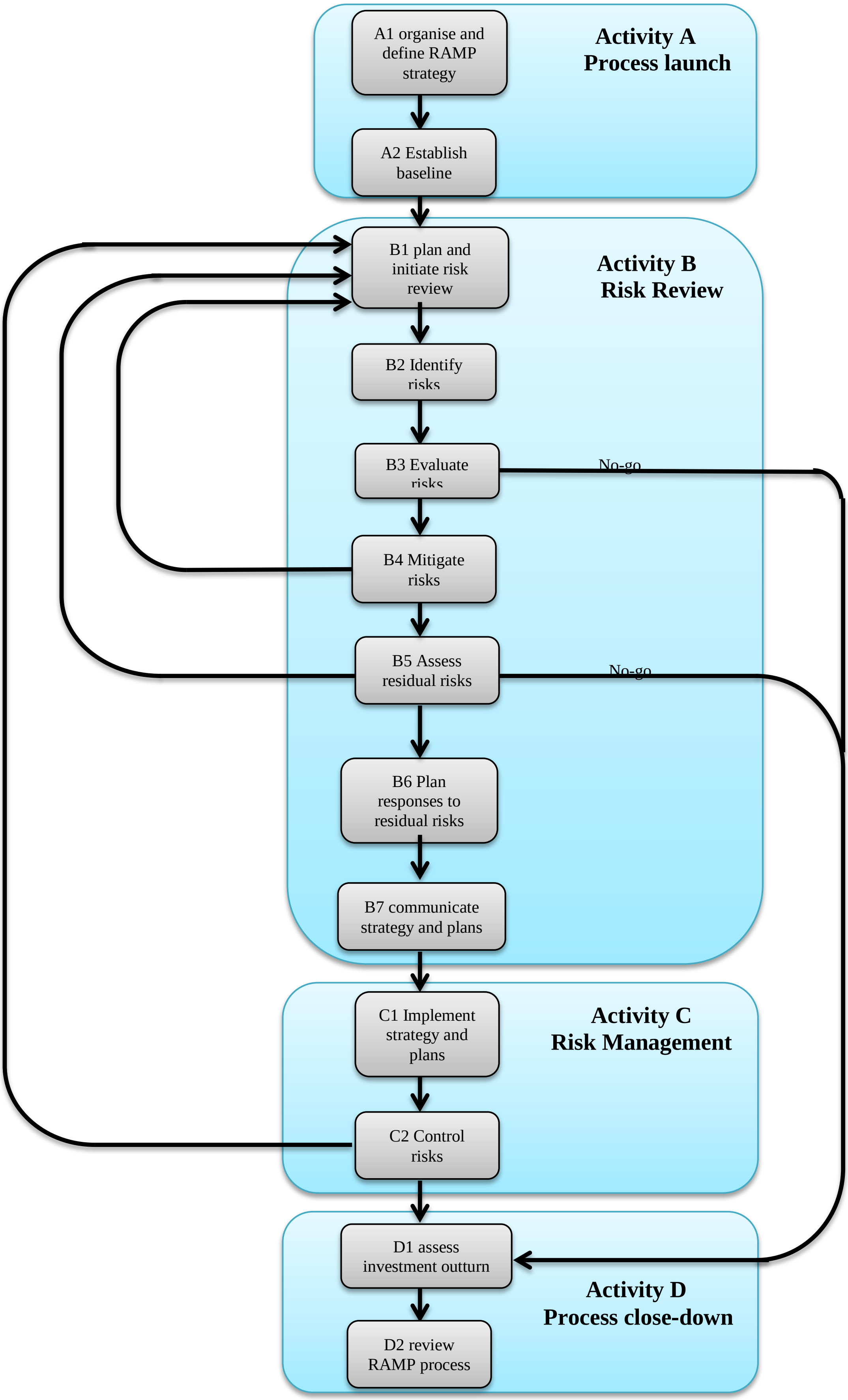


Figure 2.9: Flowchart of the overall RAMP process

Source: ICE et al (2005)

Figures 2.7, 2.8 and 2.9 provide the flowcharts of the risk management processes that are proposed by these three models (CIRIA, PRAM and RAMP). Risk management process is not a once and for all process; it must be undertaken continually and consistently throughout the project lifecycle (ICE et al, 2005). These risk management processes contain the same critical steps although they are described differently in terms of names and details. These risk management processes identified here provides a guide in the development of a conceptual risk management framework for building construction projects in developing countries.

2.7 Bayesian Belief Networks

Bayesian Belief Network (BBN) modelling, also called Bayesian Network (BN) modelling, was first reported as a method for studying inference by Dempster in the 1970s and Shachter in the 1980s (Kjaerulff and Madsen, 2008). Generally, Bayesian belief networks (BBN) are multivariate statistical models, acknowledged for their unique probabilistic modelling approach and their high model transparency (Landuyt et al, 2013). They are used for knowledge representation and reasoning under conditions of uncertainty whic have become increasingly popular for modelling complex domains for which knowledge and data are uncertain. They have proven effective for capturing and integrating quantitative and qualitative information from various sources (Smith et al, 2007), and thus have the ability to strengthen decisions when empirical data are lacking. Due to the Bayesian nature of the approach, Bayesian belief networks provide both diagnostic and predictive capabilities and allow for updating the probability distributions with new evidence when such become available.

Bayesian belief network consists of nodes, representing variables of the domain, and arcs, representing dependence relationships between nodes. Figure 2.10 shows a simple belief network in which the node at the tail of the arrow, referred to as the parent node, directly affects the node at the head of the arrow, referred to as the child node (Luu et al, 2009). An edge represents the cause-effect relationship between the parent node and the child node and child nodes are conditionally dependent upon their parent nodes (Luu et al, 2009).

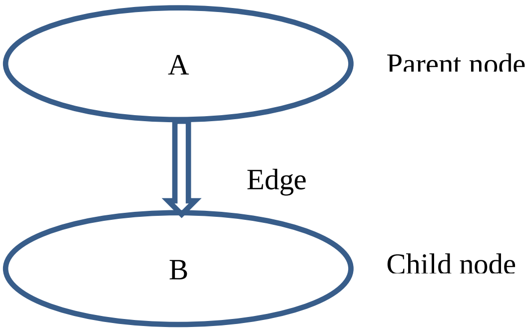


Figure 2.10: A simple Bayesian belief network

Source: Luu et al (2009)

It is frequently applied in real-world problems such as diagnosis, forecasting, automated vision, sensor fusion, and manufacturing control (Heckerman et al, 1995). It has been extended to other applications including transportation (Ulegine et al, 2007), ecosystem and environmental management (Uusitalo, 2007). Bayesian belief network has been applied in the construction industry especially in the area of construction risk management. Trucco and Leva (2012) have proposed BBN as a method to model operational risks and they provided the list of literature for BBN operational risk application. Chin et al. (2009) developed a project risk network during new product development. Lee et al. (2009) applied Bayesian belief network to risk management in a large engineering project within the ship building industry by focusing on budget, time schedules and specification discontent. Khodakarami and Abdi (2014) proposed a quantitative assessment framework integrating the inference process of Bayesian networks to the traditional probabilistic risk analysis. Fan and Yu (2004) developed a BBN based procedure using a feedback loop to predict potential risks, identify sources of risk and advise dynamic resource adjustment. Luu et al (2009), applies the Bayesian belief network to quantify the probability of construction delays in the Vietnam construction industry. However, in construction research as well as many other fields, data and parameters often have continuous values. Bayesian networks can, however, deal with continuous variables in only a limited manner and this has been identified as a major challenge (Uusitalo, 2007).

2.7.1 Bayesian Probability

According to Pearl (2000), in the Bayesian interpretation of probability encode degrees of belief about events in the world and data are used to strengthen, update, or weaken those degrees of belief. In this formalism, degrees of belief are assigned to propositions (sentences that take on true or false values) in some language, and those degrees are combined and manipulated according to the rules of probability calculus.

In Bayesian probability, therefore, the mathematical theory of probability is applied to the degree to which a belief is considered probable (Lampis, 2010). In this context, the Bayes' theorem gives a criterion for updating belief when new knowledge is introduced. This process is called Bayesian Inference. This subsection gives a brief summary of the most important concepts of probability theory considered under this approach.

A probabilistic model (or a probability space) is described as an encoding of information that permits the computation of well-formed sentence S in accordance to three axioms (Pearl, 2000). According to Spiegel, Schiller and Srinivasan (2001), given a sample space S, if S is discrete, all subsets correspond to events and conversely; if S is non-discrete, only special subsets (called measurable) correspond to events. To each event A in the class C of events, we associate a real number P (A). The P is called a probability function, and P (A) the probability of the event, if the following axioms are satisfied (See appendix B for probability and statistics symbol table).

Axiom 1. For every event A in class C,

$$P(A) \geq 0$$

Axiom 2. For the sure or certain event S in the class C,

$$P(S) = 1$$

Axiom 3. For any number of mutually exclusive events $A_1, A_2, \ldots,$ in the class C,

$$P(A_1 \cup A_2 \cup \ldots) = P(A_1) + P(A_2) + \ldots$$

In particular, for two mutually exclusive events A_1 and A_2,

$$P(A_1 \cup A_2) = P(A_1) + P(A_2)$$

2.7.1.1 Theorems on Probability

Spiegel et al (2001) reports that the above axioms prove various theorems on probability that is important in further works.

Theorem 1-1: If $A_1 \subset A_2$, then (*1*)

$$P(A_1) \leq P(A_2) \text{ and } P(A_2 - A_1) = P(A_1) - P(A_2)$$

Theorem 1-2: For every event A, (*2*)

$$0 \leq P(A) \leq 1,$$

i.e., a probability between 0 and 1.

Theorem 1-3: For $\emptyset$, the empty set, (*3*)

$$P(\emptyset) = 0$$

i.e., the impossible event has probability zero.

Theorem 1-4: If A' is the complement of *A*, then (*4*)

$$P(A') = 1 - P(A)$$

Theorem 1-5: If $A = A_1 \cup A_2 \cup \ldots \cup A_n$, where $A_1, A_2, \ldots, A_n$ are mutually exclusive events, then

$$P(A) = P(A_1) + P(A_2) + \ldots + P(A_n) \quad (5)$$

Theorem 1-6: If *A* and *B* are any two events, then (*6*)

$$P(A \cup B) = P(A) + P(B) - P(A \cap B)$$

More generally, if A_1, A_2, A_3 are any three events, then

$$P(A_1 \cup A_2 \cup A_3) = P(A_1) + P(A_2) + P(A_3) - P(A_1 \cap A_2) - P(A_2 \cap A_3) - P(A_3 \cap A_1) + P(A_1 \cap A_2 \cap A_3).$$

Generalizations to *n* events can also be made.

Theorem 1-7: For any events *A* and *B*, (*7*)

$$P(A) = P(A \cap B) + P(A \cap B')$$

If a sample space *S* consists of a finite number of outcomes $a_i, a_2, \ldots, a_n$, then by Theorem 1-5,

$$P(A_1) + P(A_2) + \ldots + P(A_n) = 1 \quad (8)$$

Where $A_1, A_2, \ldots, A_n$ are elementary events given by $A_i = \{a_i\}$.

According to Spiegel et al (2001), it follows that one can arbitrarily choose any non-negative numbers for the probabilities of these simple events as long as the previous equation is satisfied. In particular, if one assumes equal probabilities for all simple events, then

$$P(A_k) = \frac{1}{n} \quad , k = 1, 2, \ldots n \quad (9)$$

And if *A* is any event made up of *h* such simple events, we have

$$P(A) = \frac{h}{n} \quad (10)$$

This is equivalent to the classical approach to probability and one can of course use other procedures for assigning probabilities, such as frequency approach (Spiegel et al, 2001).

2.7.1.2 Conditional Probability

According to Spiegel et al (2001), let A and B be two events such that P (A) > 0. Denote P (B | A) the probability of B given that A has occurred. Since A is known to have occurred, it becomes the new sample space replacing the original S. From this we are led to the definition

$$P\ (B/A) = \frac{\mathrm{P\ (A \cap B)}}{\mathrm{P\ (A)}} \qquad (11)$$

Or

$$\mathrm{P}\ (A \cap B) = \mathrm{P\ (A)\ P\ (B/A)} \qquad (12)$$

Theorem 1-8: For any three events *A1*, *A2*, *A3*, we have

$$P\ (A_1 \cap A_2 \cap A_3\ ) = P(A_1)P(A_2 \mid A_1)P(A_3 \mid A_1 \cap A_2\ ) \qquad (13)$$

According to Spiegel et al (2001), in words, the probability that A_1 and A_2 and A_3 all occur is equal to the probability that A_1 occurs times the probability that A_2 occurs given that A_1 has occurred times the probability that A_3 occurs given that both A_1 and A_2 have occurred. The result is easily generalized to *n* events.

Theorem 1-9: If an event *A* must result in one of the mutually exclusive events $A_1, A_2, \dots, A_n$, then $P(A)$

$$= P\ (A_1)\ P\ (A \mid A_1) + P\ (A_2)\ P\ (A \mid A_2) + \dots + P\ (A_n)\ P\ (A \mid A_n) \qquad (14)$$

2.7.1.3 Independent Events

As reported by Spiegel et al (2001), if P (*B* | *A*) = P (*B*), i.e., the probability of *B* occurring is not affected by the occurrence or non-occurrence of *A*, then we say that *A* and *B* are *independent events*. This is equivalent to

$$P\ (A \cap B) = P\ (A)\ P\ (B) \qquad (15)$$

Notice also that if this equation holds, then A and B are independent.

We say that three events A1, A2, A3 are independent if they are pairwise independent (Spiegel et al, 2001).

$$P\ (A_j \cap A_k) = P\ (A_j)\ P\ (A_k)\ j \neq k \text{ where } j,k = 1,2,3 \qquad (16)$$

and

$$P\ (A_1 \cap A_2 \cap A_3\ ) = P(A_1)P(A_2\ )P(A_3) \qquad (17)$$

Both of these properties must hold in order for the events to be independent. Independence of more than three events is easily defined (Spiegel et al, 2001).

2.7.1.4 Bayes Theorem or Rule

According to Spiegel et al (2001), suppose that A_1,A_2, … , A_n are mutually exclusive events whose union is the sample space S, i.e., one of the events must occur. Then if A is any event, we have the important theorem:

Theorem 1-10 (Bayes' Rule):

$$P\ (A_k/A) = \frac{\mathrm{P}\ (A_k)\ \mathrm{P}\ (A/A_k)}{\mathrm{P}\ (A_j)\mathrm{P}\ (A/A_j)} \qquad (18)$$

This enables us to find the probabilities of the various events A_1,A_2, …, A_n that can occur. For this reason Bayes' theorem is often referred to as a theorem on the probability of causes (Spiegel et al, 2001).

2.7.2 Conceptual Modelling Development

Bayesian belief network (BBN) risk model for building construction projects should be able to link their perceptions by considering the boundary of stakeholders' perceptions on building construction project process. According to the precise definition given in quantitative modelling for risk analysis, risk is "a random event that may possibly occur and, if it did occur, would have a negative impact on the goal of the organisation" (Vose, 2008). That is to say there are mainly negative relationship between random adverse events and the building construction project goal of the organisation. Since the relationship between strategic goals and building construction project performance measurement is important (Beamon, 1999; Stevenson and Spring, 2007), the building construction project goal should be broken down to measurable event level through a combination of performance measures (Melnyk, Stewart and Swink, 2004).

The use of BBN in risk management is somewhat limited. For example, pioneering its application in construction, Fan and Yu (2004), incorporated the Bayesian belief network in a risk management decision support system based on the assumption that if more resources are added to project activities the cost of these activities will increase while the risk may be lower. The BBN come into play within a feedback loop that accommodates resources to control risks after evidence is observed and updated in the network.

McCabe, AbouRizk and Goebel (1998) used the Bayesian belief networks and event simulation as a diagnostic tool for construction operations as a way to improve performance. Evidence brought to the belief network evaluates the cause of the operational problem as a way to take corrective actions.

Nasir, McCabe and Hartono (2003) present a comprehensive list of risk variables that affect project schedules. The authors constructed a belief network using schedule risks as input variables and construction activities type as output variables. When evidence of project conditions is acquired, the status of input variables is updated; output nodes that represent percentage of increase or reduction of activity durations are then inferred. The model provides lower and upper distribution limits as a percent of the most likely duration.

Furthermore, building construction performance is not only relevant to the building construction goal but also links to building construction risk or adverse events, as confirmed by a variety of studies, for example by empirical study (Odimabo, Oduoza and Suresh 2015), questionnaire survey (Agyakwa-Baah and Chileshe, 2010) and by proposing a framework for building construction project risk assessment (Jaskowski and Biruk, 2011) etc.

As a result, the main focus for risk modelling by the logical relationship between effect (represented by building construction risk performance) and cause (represented by adverse events) as shown in figure 2.11.

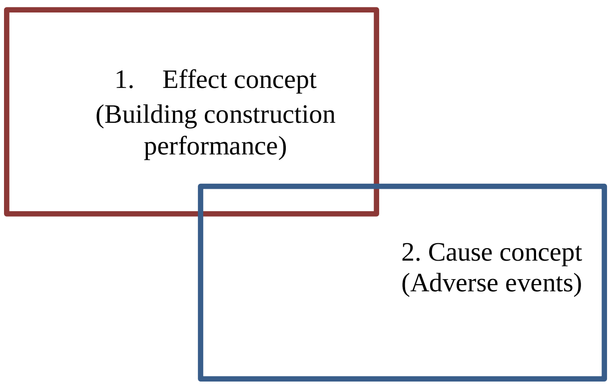


Figure 2.11: The two main concept of the initial conceptual modelling framework

The cause and effect concept can be developed and broken down into components by defining causal pathways in the conceptual elements that support Bayesian belief network building construction risk modelling. The components are first examined from the literature within construction projects risk and Bayesian belief network, to integrate both areas before proposing the Bayesian belief network building construction project risk conceptual modelling framework.

A variable in Bayesian belief network literature has been classified into leaf variable/symptom variable, root variable/background information variable, and intermediate variable/mediating variable (Kjaerulff and Madsen, 2008; Korb and Nicholson, 2004). The Institution of Civil Engineers (ICE, 2015), the Association of Project Management (APM, 2004) and the Construction Industry Research and Information association (CIRIA, 2015) have taken an initiative to define risk management as a cyclical process which is made up of the following critical steps: definition of objectives, risk identification and assessment (also known as qualitative risk analysis), quantitative risk analysis, risk mitigation and monitoring. In recent years, Fenton and Neil (2012) suggested classifying Bayesian belief network variables involved in risk analysis as risk consequence, risk event, trigger, control and mitigating event. The components in Bayesian belief network and risk especially in building construction projects are similar as can be shown in Figure 2.12.

After relevant conceptual components are defined, the causal pathways of those components are considered in order to show how Bayesian networks can capture systemic risks at the concept level. Cause-effect relation is selected (from possible types of relationship given by Neil et al. (2000); see appendix C) as the main type of relationship to capture interaction among adverse events by the Bayesian belief network building construction project risk modelling model. The risk consequence/leaf variable/symptom is identified by building construction project performance (Y) in the effect concept by linking from intermediate event (X) and root cause (Z), called the root cause/background information/risk driver/trigger. The final component is mitigating strategy (W) which can be a control and risk mitigating strategy in the mitigating concept. Mitigating actions are generally of two types: reducing the probability of adverse events (in the cause concept) or reducing negative impact on the building construction risk performance by different actions (The Royal Society, 1992; Viswanadham, Gaonkar, Tang, Teo and Wei, 2008) as shown in Figure 2.13.

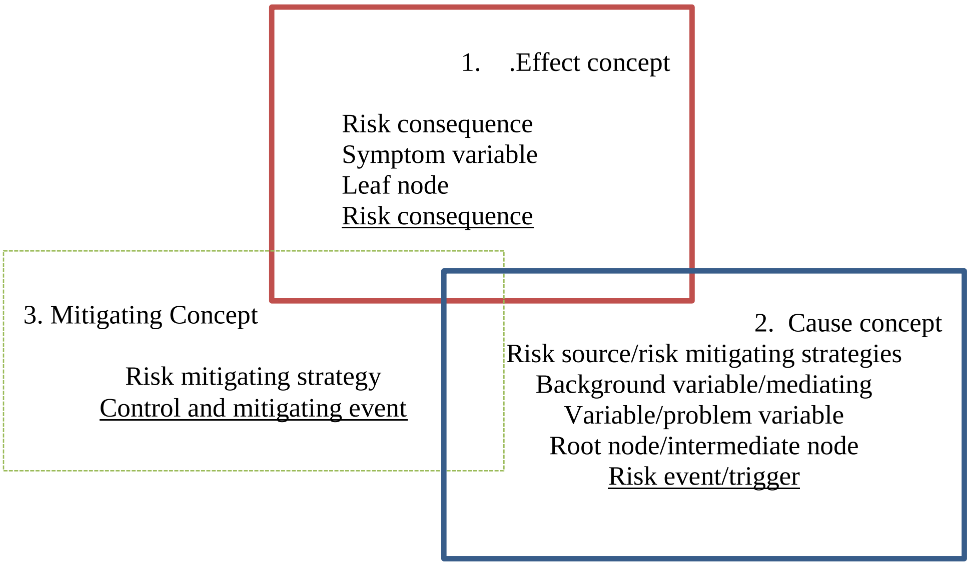


Figure 2.12: The component analysis of the initial conceptual modelling framework

Source: Lead from Kjaerulff and Madsen (2008), Korb and Nicholson (2004), Fenton and Neil (2012)

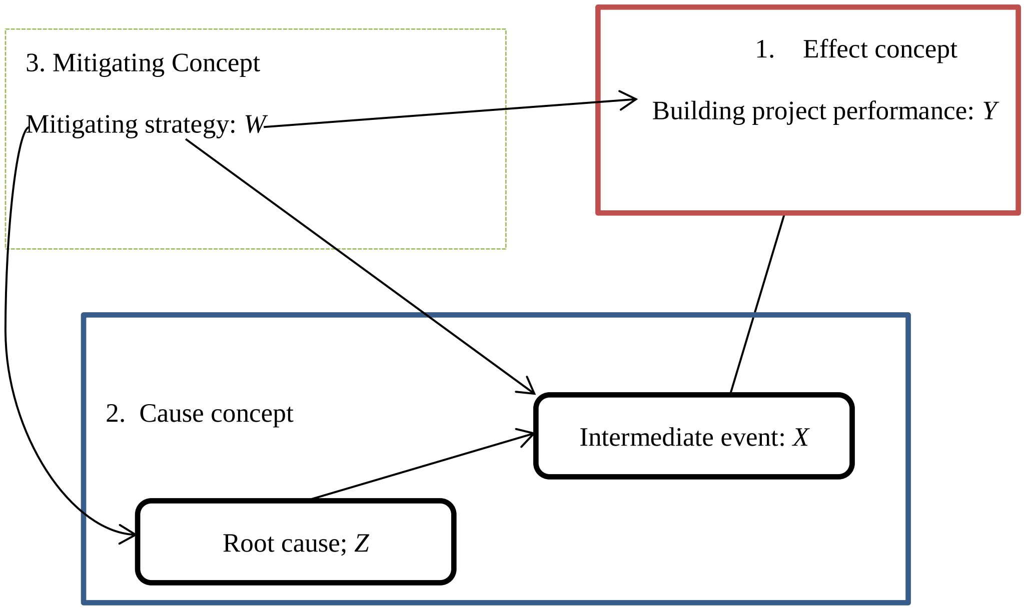


Figure 2.13: Bayesian belief network modelling framework.

Source: Modified from Kjaerulff and Madsen (2008), Korb and Nicholson (2004), Fenton and Neil (2012)

The conceptual modelling framework shows the high level components and possible causal relations needed to capture risk in this research. For the next stage, the main defined concepts are also analysed to provide the basic knowledge for individual concepts in order to be able to understand the causal-effect relationship in this context. Therefore, the three main concepts (effect, cause and mitigation) will be applied in building construction project risk context.

2.7.2.1 Issues of Concern in the Bayesian Belief Network Modelling Process

According to Nadkarni and Shenoy (2001), four criteria are of concern for Bayesian belief network structuring. They are;

1. Conditional independence: Conditional independence is required when implementing for Bayesian belief network inference to help control the structure of the for Bayesian belief network which is different from other qualitative maps. The process for checking conditional independence of the BBN structure can be applied.
2. Loops must be eliminated, or two-way arrows adjusted to one-way arrows: The Bayesian belief network map must present only links between variables without a cycle connection. A cycle is said to exist if a variable is an ancestor, and also descendant of itself and a graph is connected if there exists at least one path between every pair of variables. Therefore, there are no loops or feedback loops in the for Bayesian belief network.
3. The direction of links is from cause to effect: Cause-consequence or cause-effect is the main relationship for quantitative Bayesian belief network structuring in this research although some other relationships can also be modelled by Bayesian belief network (see Appendix C)
4. Including only direct relationships: Distinguishing direct and indirect cause-effect relations can help to reduce the number of less relevant variables and indirect links.

2.7.3 Challenges in Implementing Bayesian Belief Network to Support Risk Assessment in Construction Projects

The application of the Bayesian belief network is known to be as much an art as science, especially when constructed by expert knowledge (Druzdzel and Simon, 1993; Houben, 2010). Therefore, the success of a Bayesian belief network model implementation in this context depends on the process design. However, it has in general been difficult to find a Bayesian belief network process that was completed by using expert domains (Houben, 2010). Most studies have to adjust their Bayesian belief network protocol from one used in the professional community in general contexts to be suitable in their own contexts (Morgan and Henrion, 1990). The implication is that to support risk analysis in construction projects, Bayesian belief network should be adjusted in the light of challenges from application contexts.

2.7.3.1 Ability to Deal with Complex Construction Project Risks and Time Issues – Process Should Be Efficient and Not Invasive

Well-calibrated and unbiased probability assessment techniques suffer from the problem of being time consuming (Druzdzel and van der Gaag, 2000). For practical reasons, a compromise has to be reached between quality and limitation of resources. The fact that the process is time-consuming is a significant barrier to the success of the model development since "the time of genuine experts is seriously limited and may be expensive" (O'Hagan, 2005). Furthermore the model is more complex and the process is more time consuming when the model to be developed is in the large scale construction project, involving multiple experts and different stakeholders. Therefore, the Bayesian belief network modelling for this study, which will be implemented with genuine experts, requires an efficient process.

2.7.3.2 Scoping the Risk Analysis

According to Leerojanaprapa (2014), the following criteria should be considered when modelling Bayesian belief network. These are;

1. Bounding of the scope; Guidelines on how to define the construction project scope should be explained in the Bayesian belief network modelling process.
2. Identifying relevant stakeholders who understand the system within the building construction risk scope: The boundary of the building construction project should be defined by including the relevant stakeholders who can take a part in developing the model. Numbers of stakeholders can represent number of modelling team and efforts to be taken for collecting data. How to invite them and make them trust to share their adverse events with their stakeholders are the practical concerns
3. Defining outcome measures: The BBN model is useful since it can provide a variety of analysis, but providing the modelling measures to support risk analysis is also a main challenge.

2.7.3.3 Thinking about Possible Future Risk Events and Relationships

Bayesian belief network is a qualitative and quantitative model and generally Bayesian networks can be structured and quantified by data record and/or knowledge of experts (also known as expert judgement).

1. Identifying and quantifying causal relationships in the building construction process: Underpinning the construction project process is the basic understanding of how to identify adverse events and the causal relationships. The problem structuring process for qualitative Bayesian network should include the construction project process since logical relationships can be influenced through linking of activities in the building construction project process (Walls and Quigley, 2001).
2. Dealing with rare events which can have major systemic consequences: Some adverse events may rarely occur or have not occurred according to the company data records but if they occur, they will generate the major impact to the company (Walls and Quigley, 2001). Therefore, those adverse events which can be captured in probabilistic model. Relevant knowledge is important source for the model quantification.
3. Linking adverse events within the construction project scope under the knowledge boundary of participants in individual organisation units (Walls and Quigley, 2001).

2.7.3.4 Modelling Building Construction Project Risk Analysis at an Appropriate Level

1. Ability to deal with the perceptions of experts who may have less experience in modelling: the process should be simple and transparent: The Bayesian Belief Network model is developed by building construction operational experts from different stakeholder organisations so they may not have a lot of modelling experience or understand probability language (Leerojanaprapa, 2014). Furthermore, the expectation of the process is not just that data from expert knowledge is gathered, but also that communication of the experts or stakeholders is stimulated, thereby improving the understanding among stakeholders. Therefore, it is important that the process is simple and transparent, to enable communication between stakeholders. This is a key factor for the success of the Bayesian belief network model development in this study.
2. Focusing on key building construction project uncertainties is challenging because of the tendency to think about every activity in an operational process: It is necessary to limit the model by excluding some activities, for general limitation of using model to represent part of the reality (Leerojanaprapa, 2014).

2.7.4 Justification on choice of Bayesian Belief Network in Building Construction Risk Model

The suitable model to support construction risk analysis for this study needs to satisfy a set of criteria defined in section 2.5.4. Bayesian belief network is selected in this research for the modelling of building construction risk analysis. Bayesian belief network are probabilistic models that represent system variables and their conditional relationships graphically as nodes and linkages in an influence diagram. Bayesian belief network is a useful methodology for construction risk management with a systematic and integrated process (Lee et al, 2009). It can perform scenario analysis as either for predictions or for diagnostics (Weber et al, 2012) by setting a combination of simultaneous occurrence of a number of risk events. Bayesian belief network can represent systemic risks in a construction project process by capturing uncertainty since it can model different types of uncertainty: operational failure (McNaught and Chan, 2011; Neil et al., 2008), human error (e.g. Kim and Seong, 2006; Kim et al., 2006) or combining system related factors with human organisational factors (e.g. Ren et al., 2008; Trucco et al., 2008) etc. it can also capture complex relationship through non-deterministic dependence (i.e. be able to capture complex relation between risks or adverse events) and it is also able to capture the less complex relations. Bayesian belief networks can support measurement of construction risks by representing it through probability language which is defined as the nature of risk assessment (Williams, 2000). Bayesian networks represent logical relationships so it can simplify the complex demands of modelling inputs and deal with a number of adverse events including rare and high impact events such as using Bayesian belief networks to analyse human fatality risk in building fires (Hanea and Ale, 2009). Finally, Bayesian belief network can be used to support risk communication between stakeholders if they want to decide for mitigating risks with their stakeholders.

The possibility of developing a model in practice; the cost of the modelling software should be considered.

2.7.5 Choice of Decision Software for Bayesian Belief Network

In the course of this research, a Bayesian belief network was constructed by structural learning and parameter learning using the Netica 5.0 application software. According to Norsys Software Corporation (2015) Netica is a powerful, easy-to-use, complete program for working with belief network and influence diagrams. It has an intuitive and smooth user interface for drawing the networks, and the relationships between variables may be entered as individual probabilities, in the form of equations, or learned from data files (Norsys Software Corporation, 2015).

Netica can use the networks to perform various kinds of inference using the fastest and most modern algorithms. Given a new case of which we have limited knowledge, Netica will find the appropriate values or probabilities for all the unknown variables. These values or probabilities may be displayed in a number of different ways, including bar graphs and meters (Norsys Software Corporation, 2015). The case may conveniently be saved to a file, and later brought back into the network (or a different network) for further querying, or to take into account new information about the case. Netica can use influence diagrams to find optimal decisions which maximize the expected values of specified variables. Consequently, Norsys Software Corporation (2015), reports that Netica can construct conditional plans, since decisions in the future can depend on observations yet to be made, and the timings and inter-relationships between decisions are considered.

According to Norsys Software Corporation (2015) some of its features and capabilities includes but is not limited to;

- It generates presentation quality graphics which can be incorporated into documents.
- It complies Bayesian networks into a junction tree of cliques for fast probabilistic reasoning.
- It has an extensive built in and online help.
- It conducts utility-free sensitivity analysis.
- It can generate highly customizable report on much aspect of the Bayes net, nodes, states, CPT’s cases, findings, beliefs, sensitivity results, other interference result, etc.
- It has a facility for the easy discretization of continuous variables.

2.8 The Proposed Risk Management Framework for Building Construction Projects in Developing Countries

Through a careful study and adoption of the results of other researches such as those of Seo and Choi (2008), Lee et al (2009) and Aloini et al. (2012) a research framework was developed suitable for elaborate risk assessment of building construction projects especially for developing countries. The study adopts the Bayesian belief network

(BBN) for risk management which avoids, transfers, shares, retains, reduces or ignores potential risk in a building construction environment. Figure 2.14 shows a flow scheme for implementing Bayesian belief network for building construction projects.

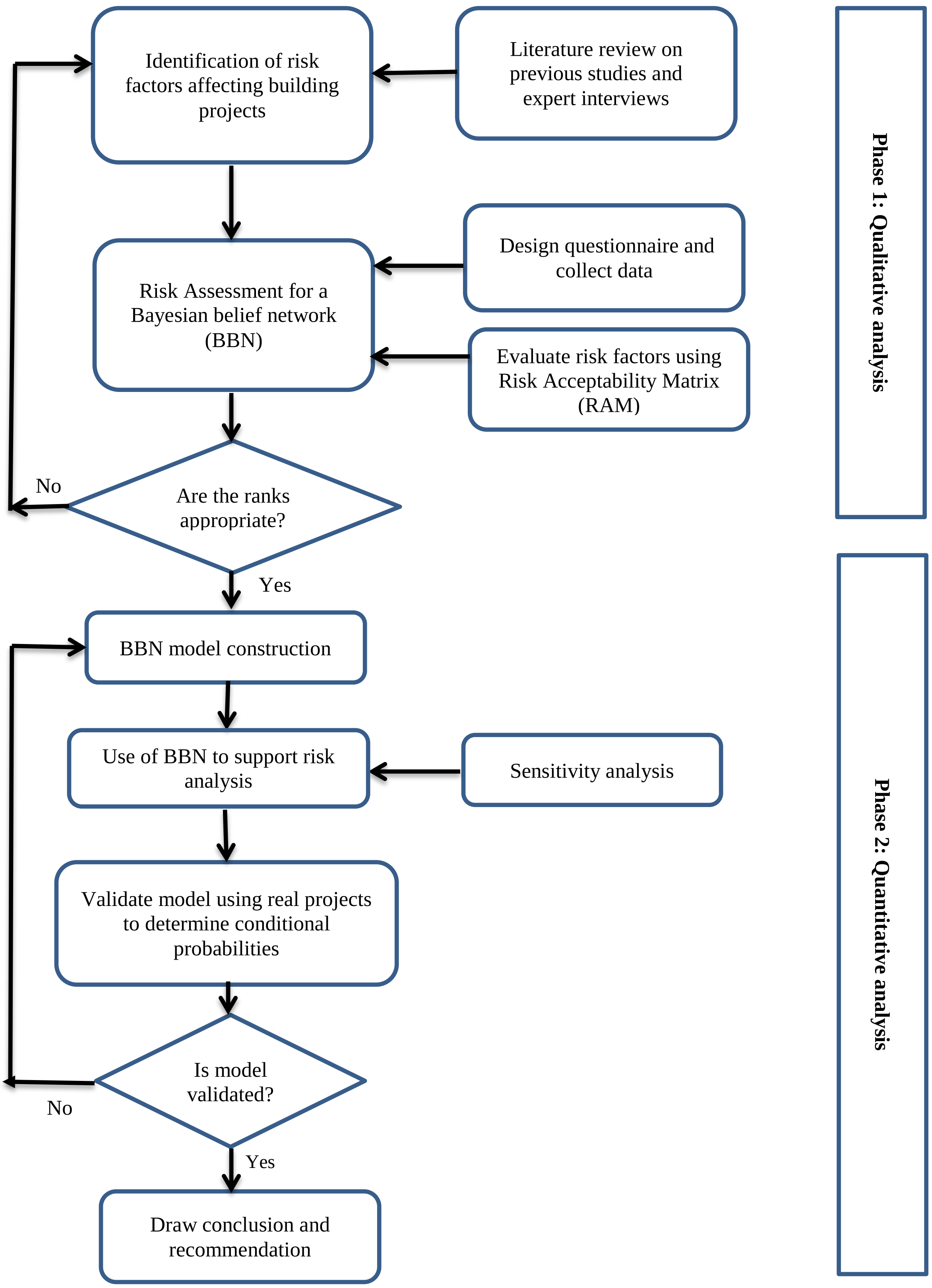


Figure 2.14: Proposed risk management framework for building construction projects using Bayesian belief network

(Developed by the researcher)

2.8.1 Risk Classification and Identification

Table 2.2 show risks factors that affect construction projects as highlighted by other researchers.

Table 2. 2: Different source of risks in construction projects in developing countries

Construction project	**Risk Classification**	**Authors**
Construction projects in China	1. Risk related to clients 2. Risk related to designers 3. Risk related to contractors 4. Risk related to contractors/suppliers 5. Risk related to government 6. External issues	Zou et al (2007)
UAE construction industry	1. Owner risk 2. Design risk 3. Contractor risk 4. Subcontractor risk 5. Supplier risk 6. Political risk 7. Social and cultural risk 8. Economic risk 9. Natural 10. Others	El-Sayegh (2008)
Building construction	1. Project management risk 2. Engineering risk 3. Execution risk 4. Suppliers risk	Nieto-Morote and Ruz-Villa (2011)
Land-based construction	1. Natural • Weather system • Geological system 2. Human • Social • Political • Economic • Financial • Legal • Health • Managerial • Technical • Cultural	Edward and Bowen (1998)
Metropolitan construction projects	1. Engineering design 2. Construction 3. Construction safety-related 4. Natural hazards 5. Socio-economic	Kuo and Lu (2013)
Shipbuilding projects	1. Natural 2. Political 3. Legal 4. Social 5. Economic 6. Financial 7. Technical 8. Managerial	Lee et al (2009)
International construction projects	1. Technical 2. Managerial 3. Resource	Dikmen et al (2007)

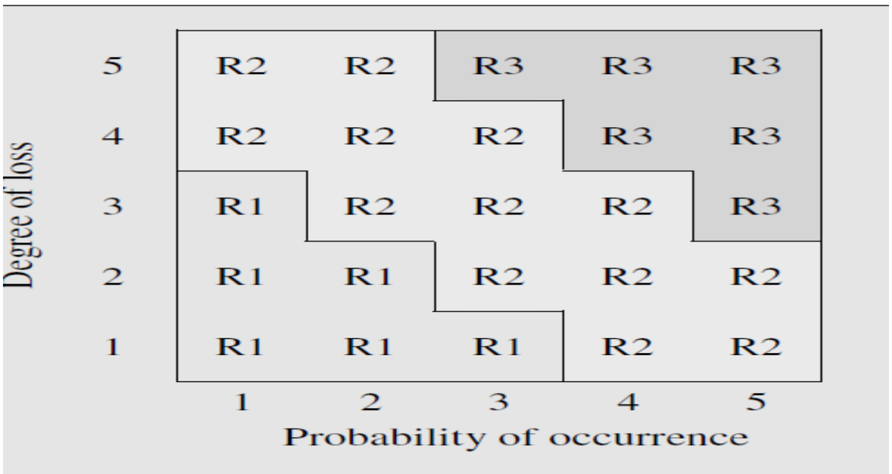
	4. Productivity 5. Design 6. Payment 7. Client 8. subcontractors	
Building construction in developing countries	1. Physical 2. Environmental 3. Design 4. Logistics 5. Financial 6. Legal 7. Construction 8. Political 9. management	Ugwoeri (2012)

Different approaches can be used to classify the risks associated with engineering construction projects and the rationale for choosing a method must serve the purpose of the research. In this research, building construction risk where classified into **physical** (Supplies of defective materials, Vandalism), **environmental** (Flood, rain effect on construction activities), **design** (Inaccurate quantities, Rush design), **logistics** (High competitions in bids, undefined scope of working), **financial** (Unmanaged cash flow, delayed payment in contract), **legal** (legal disputes during construction phase among parties, patent right), **construction** (improper construction methods, shortages of qualified and specialized companies), **political** (lack of transparency, political orientation) and **management risk** (Resource management, ambiguous planning due to project complexity).

2.8.2 Risk Assessment for a Bayesian Belief Network

This section describes how the level of each risk item identified in a building construction project is measured and the collected data is modified for a Bayesian belief network analysis. The risk severity has been determined by Kuo (1998) using the degree of loss and the probability of occurrence. The collected data is modified using the risk matrix shown in Figure 2.15 - to apply a Bayesian belief network.

$$\text{Risk} = (\text{the degree of loss}) \times (\text{the probability of occurrence}) \qquad (19)$$



Low risk level: R1, High risk level:

Figure 2.15: *Risk matrix for Bayesian belief network*

Source: Lee et al (2009).

With lead from Abujnah and Eaton (2010), this research measures the probability (likelihood) of occurrence and the magnitude of impact of risk factors on building construction projects on a five-point Likert scale as shown in table 2.3 and 2.4 respectively.

Table 2. 3: Terms for quantifying risk likelihood
(Developed by the researcher)

Likelihood	***Description***	***Scale Value***
Frequent	Constant occurrence	5
Probable	Likely to occur regularly	4
Occasional	Quite often occurs	3
Rarely	Little likelihood but could well happen	2
Improbable	Unlikely but possible	1

Table 2. 4: Term for quantifying risk impact
(Developed by the researcher)

Impact	***Description***	***Scale Value***
Extreme	Project could not be sustained (e.g. bankruptcy)	5
Great	Serious threat on project	4
Moderate	Medium effect on project	3
Little	Small effect on project	2
Negligible	Trivial effect on project	1

The risk level was simulated using a risk matrix for performing analysis of a Bayesian belief network.

2.8.3 A Bayesian Belief Network Construction

A Bayesian belief network is constructed by structural learning used to examine the relationships among risk variables (Lee et al, 2009). Consequently, the conditional probability of each risk variable can be calculated by parameters learning using several software packages for decision support that have been developed such as GeNle, Netica, Hugin, Matlab, Analytica, C++, FC BeNe, AgenaRisk and ICMS (Lee et al, 2009; Ticehurst et al 2007; Molina et al, 2010; Perez-Minana et al, 2012; Park and Stenstrom, 2006; Adriaenssens et al, 2004).

A Bayesian belief network was constructed by structural learning and parameter using Netica, which is decision-support software (see section 2.7.5).

2.8.4 Use of BBN to Support Building Construction Risk Analysis

Following the construction of the Bayesian belief network, sensitivity analysis is carried out using the Netica software which efficiently measures the degree to which findings at any node can influence the beliefs at another node, given the findings currently entered (Lee et al, 2009). The measures are in the form of mutual information (entropy reduction), or the expected reduction of real variance. Sensitivity is represented by entropy: a larger entropy between nodes produces a bigger influence (Lee et al, 2009).

Important risk factors that should be controlled were selected as presented. Entropy reduction (mutual information) values were calculated for sensitivity analysis of risk factors related to project performance. The results from sensitivity analysis will help experts judge how best to use the model to support risk analysis, by comparing the result of analysis with their perceptions.

2.8.5 Validate BBN Building Construction Model

Validation can be evaluated whether or not the model provides an appropriate representation of the real world (Finlay, Forsey and Wilson, 1988; Watson and Buede, 1994). Validation means knowing whether the right answer or the true value is known. A summary of the criteria for validation from literature (Houben, 2010; Korb and Nicholson, 2004) is given in Table 2.5.

Table 2.5: Bayesian belief network model validation criteria when values are unknown ***(Adapted from Houben, 2010; Korb and Nicholson, 2004).***

Related Process	Criteria
Model structure by expert panel	1. Clarity test Do all variables and their state have a clear operational meaning to all stakeholders? 2. Variable definitions and relation checking Are they named usefully? Are state values appropriately named? Are all relevant variables (under the modelling scope and assumption) included?
Process to achieve different perception by modeller	3. Consistency checking Are the state dimensions across different eliciting questions consistent? Are all state values useful or can some be combined?
Model analysis outcome by expert panel	4. Model robustness (Sensitivity analysis) Are the sensitivity analysis results acceptable for experts? Or are the ranges of concerned variables specified in the map? (Include or exclude some variables). 5. Model behave appropriately (Scenario analysis) Are experts comfortable with the results of the scenario testing?

The BBN model analysis outcome also is validated by showing sensitivity analysis to experts and asking for their perceptions (Houben, 2010). Therefore, a case study is used in this research to validate the outcomes of the model to support risk analysis for building construction projects. This is literally the last stage of the risk management process.

2.9 Chapter Summary

This chapter introduced the basic concepts and general terminology related to risk management. It also explained the benefits of the implementation of systematic risk management to various project stakeholders. The guidelines provided by the Institution of Civil Engineers (ICE), the Association of Project Management (APM), and the Construction Industry Research and Information Association (CIRIA) have been critically reviewed to define the criteria required for successful risk management. Consequently, the combination of Bayesian belief network theory and Bayesian belief network process in literature helps to identify the issues of concern to the design of the modelling process for this research. A construction risk management framework using Bayesian Belief Network is presented which is used in a building construction project. An application of the Bayesian belief network methodology will apply using the context of the framework in the later part of this research. Implementing BBN in building construction project risk context is a novel application in a new field which involves operational multidisciplinary experts; suitable techniques should be carefully considered, especially as the perceptions of participants. Consequently, it is necessary to define the essential steps for practical risk management which is necessary to develop a risk management system that would manage risk factors in the Nigerian construction industry. This is developed in the following chapters.

CHAPTER THREE: CONSTRUCTION PROJECT PERFORMANCE, RISK BREAKDOWN STRUCTURE AND THE RISK ACCEPTABILITY MATRIX

3.0 Chapter Introduction

This chapter provides the means to identify events that could adversely affect building construction projects. It begins by describing the effects of cost overruns, time overruns and quality problems in construction project. Consequently, this chapter reviews the literature related to the subject and presents a list of risk factors that could be responsible for cost overruns, time overruns and quality problems in the construction sector of developing countries. It further establishes what contribution the literature makes in providing the means to classify and assess events which could adversely affect construction projects. It reviews risk classification systems that have been used to categorize risk factors, hence this research develops a Risk Breakdown Structure (RBS) that shows the hierarchical structure of potential risk sources that affect building construction projects in Nigeria. Also, the chapter examines previous approaches that have been utilized to measure the significance of risk factors, thus, developing a Risk Acceptability Matrix (RAM).

3.1 Project Performance Scope

Parvan, Rahmandad and Haghani (2015) consider a project as the achievement of a specified objective, which involves a series of activities and tasks that consume resources. According to Chan and Chan (2004), project success is defined as “the set of principles or standards by which favourable outcomes can be completed within a set specification”. Project success means different things to different people. Each industry, project team or individual has its own definition of success. Pariff and Sanvido (1993) consider success as an intangible perceptive feeling, which varies with different management expectations, among persons, and with the phases of project. According to Chan and Chan (2004), owners, designers, consultants, contractors, as well as sub-contractors have their own project objectives and criteria for measuring success. For example, architects often consider aesthetics rather than building cost as the main criterion for success. However, client may value other dimensions more. Moreover, even the same person's perception on success can change from project to project. Definitions on project success are dependent on project type, size and sophistication, project participants and experience of owners, etc.

Consequently, over the decade, researchers have proposed different criteria for measuring project success (Chan and Chan, 2004). Figure 3.1 presents a consolidated framework for measuring success of construction projects.

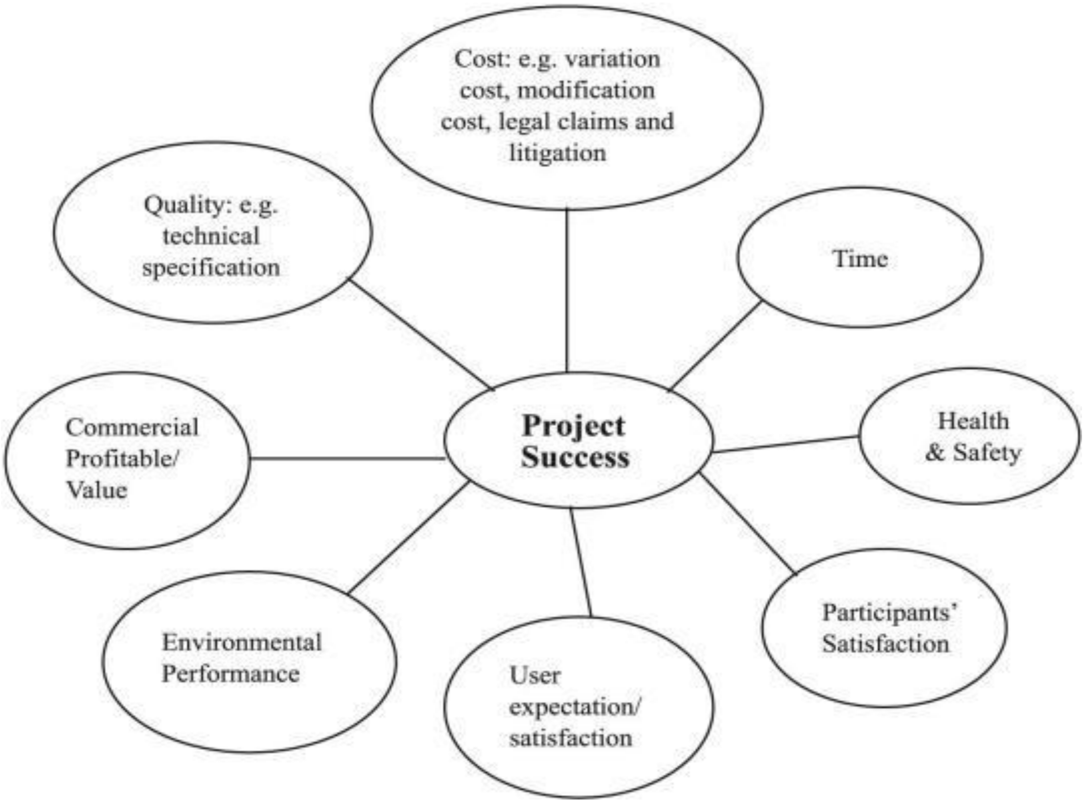


Figure 3.1: Consolidated framework for measuring project success
Source: Chan and Chan (2004)

However, construction project level success is measured by the project duration, monetary cost and project performance (Navarre and Schaan, 1990). Therefore, in this research, the following variables are used to determine project performance:

- Cost
- Time
- Quality

These variables form a system that must remain in balance for a building construction project to be in balance, because they are so important to the success or failure of the project. Each of these variables is discussed individually in the subsequent sub sections.

3.1.1 Cost

The cost of doing a building construction project is a variable that defines the project. It is best thought of as the budget that has been established for the building construction project (Wysocki, 2009). This is important for building construction projects that create deliverables that are sold either commercially or to an external customer. Cost is a major consideration throughout the project management life cycle. According to Wysocki (2009), the first consideration occurs at an early and informal phase in the life of the construction project.

The purpose of estimating cost in a building construction project is to:

- Control expenditures: The estimates are prepared as a measure against which to control costs in a construction project which is referred to as the baseline (Turner, 2014). Consequently, Turner (2014) reports that the classic control cycle has four steps and is illustrated in Figure 3.2.
    - Estimate future performance
    - Monitor actual performance
    - Calculate the difference, called the variance
    - Take action according to the size of the variance.

For this purpose, estimates may need to be quite detailed, prepared at a low level of break down.

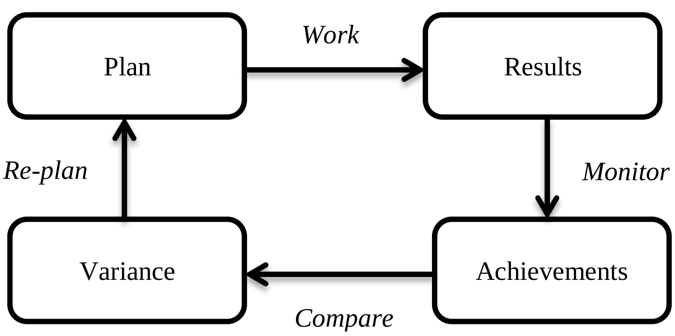


Figure 3.2: A four-step control process
Source: Turner (2014)

- Assess project viability: Before a building construction project estimate is prepared, there is a need to determine if the project is worth undertaking. Therefore, the estimates for the building construction project cost must be compared to the estimates of return (Turner, 2014). The appraisal estimates goes through various stages of increasing accuracy, at the end of each concept, feasibility and design (Turner, 2014).
- Obtain funding: After approval, funding must be obtained. Funding is awarded based on the appraisal estimates prepared at design (Turner, 2014).
- Manage Cash flow: According to Turner (2014), once funding has been obtained, and work starts, the project must be managed so that work takes place and consumes cash no faster than the rate agreed with the financiers.
- Allocate resources: Human resources are a special form of project funding as reported by Turner (2014). Businesses plan their allocation in advance against cash flow estimates which will be assigned to the project week by week against the control estimate (Turner, 2014).
- Estimate durations: The duration of a work element is calculated by comparing the estimates of work content to resource availability, and so the cost estimates form an input to time estimating (Turner, 2014).
- Prepare tenders: Contracting firms tendering modified contracts need to prepare estimates for the tenders (Turner, 2014).

Accurate cost estimating is sometimes a difficult task because it begins during project conception and well before all necessary, final information about the project is available (Nicholas and Steyn, 2008). This problem of poor cost management and overruns in project cost is a serious issue in both developed and developing countries. According to Bordat et al (2004), it can be described as the percentage difference between the final cost of the construction project and the actual contract award amount. This problem needs serious attention for improving the construction cost performance as rarely construction projects are completed within budget (Aziz et al, 2013).

3.1.2 Time

Time frame or dead-line date is being specified by the client within a building construction project (Wysocki, 2009). To an extent, time and cost are inversely related to one another. For example, the time a construction project takes to be completed can be reduced but cost increases as a result. Time can be inventoried and it is consumed whether you use it or not. According to Turner (2014), time schedule is a series of dates against the milestone and deliverables of the project, which records:

- When we forecast the work will be done
- When the work is actually done

Time is essential to the successful execution of projects because without time, it is difficult to coordinate the diverse activities found in a construction project (Luu et al, 2009). Consequently, Turner (2014) reports that the purpose of recording times and dates is:

- To ensure the benefits are obtained at a timescale that justifies expenditure
- To coordinate the effort of resources
- To enable the resources to be made available when required
- To predict the levels of money and resources required at different times so the priorities can be assigned among projects
- To meet a rigid end date

From Turner's (2014) analysis, the first point made on the purposes is the most important because it addresses the overall purpose of achieving the aim of project management. The second enables the project to happen. The third and fourth are variations while the fifth item gets the most attention from project managers because they set a rigid end date, sometimes unnecessarily, and focus on this to the detriment of cost and quality.

3.1.2.1 Project Schedule

Project schedule records the planned and actual start date, finish date, and duration of each work element (Turner, 2014). Subsequently, Turner (2014) reports that sophisticated schedules record up to five versions of each of the start date, finish date, duration, and float: the early, late baseline, schedule and actual dates.

The Duration: this is the time required to do the work.

Early and Late Dates: these are forecast from the estimated duration of all activities. The start of an activity may be dependent on other work finishing. Hence, there is an earliest date by which an activity may start and it is referred to as *early start date*. The early start date plus the estimated duration is the *early finish date*, the earliest date by which the work can finish. Consequently, other work may be dependent on the activity being finished, so there is a latest date by which it can be finished and not delay completion of the project which is referred as the *late finish date*.

Float: the flexibility when a work element can start between the late start date and the early start date.

Float = Late start date – Early start date

Planned, Baseline and Schedule dates: *Planned dates* are dates between the early and late dates when the work is determined to be done. The original measure for the project is referred to as the *baseline date*, and the current plan as the *schedule date*.

According to Turner (2014), there are up to fifteen dates and times associated with a work element as highlighted in Table 3.1. The process of scheduling the project is the assignment of values to these dates and times.

Table 3.1: *Fifteen time elements of the schedule of a project*
Source: Turner (2014)

Early start	**Duration**	**Early finish**
Late start	**Float**	**Late finish**
Baseline start	**Baseline float**	**Baseline finish**
Schedule start	**Remaining float**	**Schedule finish**
Actual start	**Remaining duration**	**Actual finish**

Where planned duration = planned finish – planned start

Planned float = late finish – planned finish

However, Bordat, McCullouch, Labi, and Sinha (2004), described time overruns as the difference between a project original contract period at the time of bidding and its overall actual period at the end of construction.

3.1.3 Quality

According to Wysocki (2009), the following two types of quality are part of every project:

I. Product quality: the quality deliverables from the project.
II. Process quality: the quality of the project management process itself. The focus is on how the project management process works and how it can be improved.

Quality is a comprehensive concept and there is no universal definition to it however, for the purpose of this research quality problems would be described as the dissatisfaction with the level of service provided and with the quality of the end product (the constructed building project) by the client (owner). According to Wysocki (2009), a project is said to be of a good quality if the output:

- Meets the specification: the output is produced in accordance with the written requirements laid down for it.
- Is fit for the purpose: the project output, when commissioned, delivers new competencies, the project outcome, which solve the problem or exploits the opportunity intended, or better.
- Meets the customer's requirements: the project output meets the requirements the customers had of it.
- Satisfies the customer: the project output and the outcome make customers feel satisfied.

Note: the customer can be the sponsor or owner of the facility, the operators of the facility, or users of the services it provides, the consumer of the eventual product it produces and finally, the media, or local community, or politician (Wysocki, 2009).

3.2 Delays in Construction Projects

The construction industry is the tool through which a society achieves its goals of urban and rural development (Enshassi, Al-Hallaq and Mohamed, 2006). However, it is becoming increasingly more complex partly because the complexity of the construction process itself and the large number of parties involved including clients, users, designers, regulators, contractors, suppliers and others (Enshassi et al, 2006). Moreover, Drewer (2001) reported that the construction industry in a developed world which is supported by the social and political infrastructure that manifest in legal systems, forms of contract and a formal accreditation of professional competence do not exist in developing countries which tend to rely on infrastructure and procedures that are borrowed from or imposed by the developing countries.

The successful execution of construction projects and keeping them within estimated cost and prescribed schedules depend on a methodology that requires sound engineering judgment (Hancher and Rowings, 1981). To the dislike of owners, contractors and consultants many of their projects experience extensive delays and thereby exceed initial time and cost estimates (Odeh and Battaineh, 2002).

In construction projects, delays are described as the time overruns either beyond completion date specified in a contract or beyond the date that the parties agreed upon for delivery of a given project (Assaf and Al-Heijji, 2006). It is a project slipping over its planned schedule and is considered as a common issue in construction projects. Consequently, it is reported by Assaf and Al-Heijji (2006) that delays could be to a client as a loss of revenue through lack of production facilities and rent-able space or a dependence on present facilities. In some cases, to the contractor, delay means higher overhead cost because of longer work period, higher material cost through inflation, and due to labour cost increases.

3.2.1 Classification of Delay

Delays in construction are caused by several factors. Ahmed, Azhar, Kappagntula and Gollapudil (2003), grouped delays into two categories – internal causes and external causes. Internal causes arise from the parties to the contract (e.g. contractor, client, and consultant). External causes, on the other hand, arise from events beyond the control of the parties. These include the act of God, government action, and material suppliers. According to Tumi, Omran and Pakir (2009), there are two categories of delays used in determining delay damages as illustrated in Figure 3.3

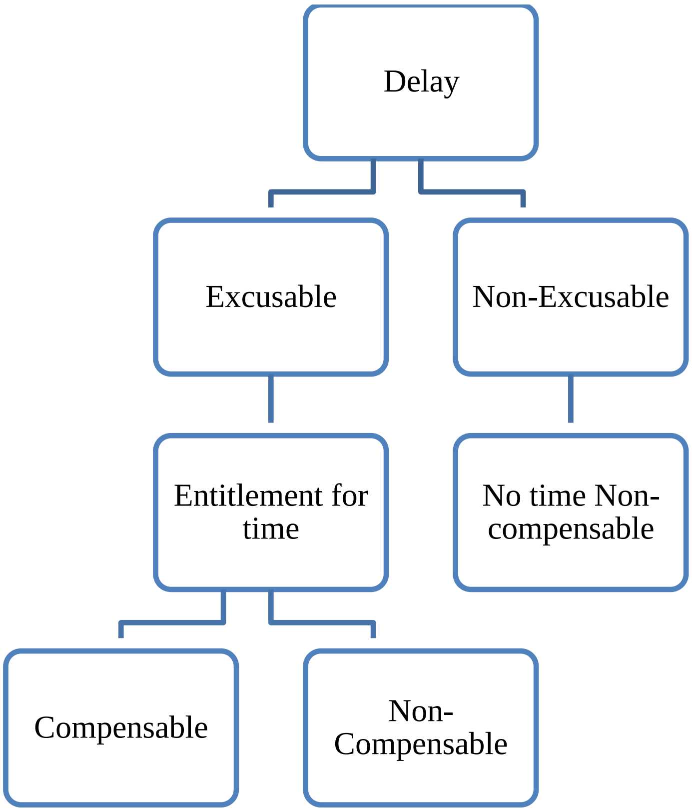


Figure 3.3: Categories of delays
Source: Tumi et al (2009)

3.2.1.1 Non-Excusable Delay

This kind of delay is caused solely by the contractors or its suppliers. The contractor is generally not entitled to relief and must either make up the lost time through acceleration or compensate the owner (Tumi et al, 2009). This compensation may come about through either liquidated damages or actual damages, providing there is no liquidated damages clause in the contact. Liquidated damages are generally expressed as a daily rate that is based on a forecast of costs the owner is likely to incur in the event of late completion by the contractor.

Consequently, Ogunlana et al. (1996) remarked that contractors handling projects in developing countries face three major challenges as shown in Figure 3.4.

- Challenges imposed by the contractor's own shortcoming
- Inaccurate information and frequent changes in instruction and failure to meet obligations on the part of clients and consultants

- Challenges imposed by the industry infrastructure, e.g. training plant availability, material supply and communication.

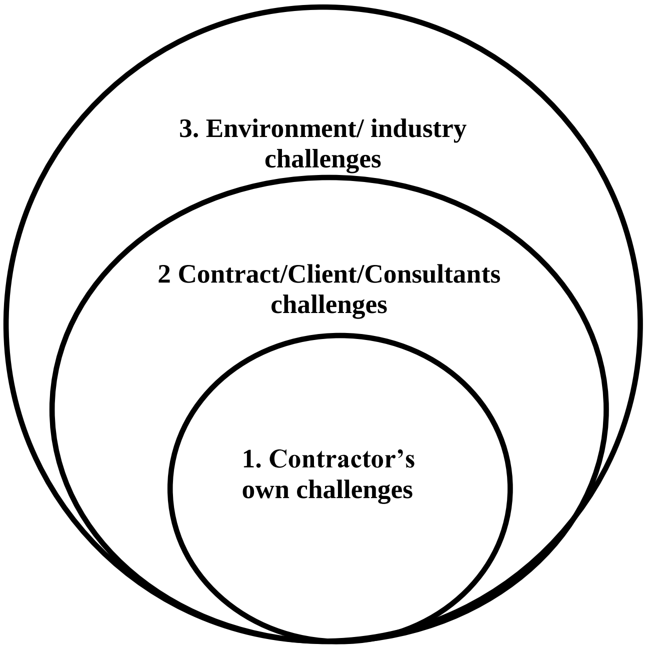


Figure 3.4: Challenges causing delays in construction projects
Source: Ogunlana et al (1996).

3.2.1.2 Excusable Delays

Excusable delays can be divided into non-compensable delays and compensable delays.

3.2.1.2.1 Non-Compensable Delays

These are caused by third parties or incidents beyond the control of both the owner and the contractor. E.g. typically include acts of God, unusual weather, strikes, fires, acts of government in its sovereign capacity, etc. In this case, the contractor is normally entitled to a time extension but no compensation for delay damages.

3.2.1.2.2 Compensable Delays

Generally, a compensable delay is caused by the owner or the owner's agents. These delays can occur under different situations. Example of this would be the late release of drawings from the owner's architect. An excusable, compensable delay usually leads to a schedule extension and exposes the owner to financial damages claimed by the contractor (Tumi et al, 2009). In this case, the contractor incurs additional indirect costs for both extended field office and home office overhead and unabsorbed home office overhead.

3.3 Identification of Risk Factors Causing Cost Overruns, Time Overruns and Quality Problems in Construction Projects in Developing Countries

It is almost certain that some building construction projects task will not be completed in line with their duration estimates and budgets as reported by Lock (2013). Risk factors can occur in any kind of construction project and they range from the 'accident waiting to happen' variety to the most unexpected and unusual (Lock, 2013).

Construction project risks include business, contract relationship, cost, funding, management, political and schedule risk. Cost and schedule risk are often so fundamental to a construction project that they may be treated as stand-alone risk categories (Kerzner, 2013). Risk identification must be carried out through all the levels of the project phase.

In this section, risk factors causing cost overruns and time overruns in building construction projects will be identified by literature review and by questionnaire survey and interviews with contractors, subcontractors and clients in the Nigerian construction industry.

3.3.1 Sources of Risks, Past Reviews on Construction Projects in Developing Countries

Different sources of construction risks in developing countries have being identified in previous studies. The sources of risk are influential to building construction performance in terms of time and cost in negative and positive ways. However, Ofori (2011), reports that the structural problems of the construction industry in developing countries are more fundamental, serious, complex and over all much more pressing than those confronting their counterparts elsewhere.

These sources of risk provide a structure that ensures a comprehensive process of systematically identifying risk to a consistent level of detail and contributes to the effectiveness and quality of the risk process identification (PMBoK, 2008). This is necessary because risk factors in construction projects cover huge areas and the linkages between them are so complicated. Risk can be classified in accordance with their occurrences at different construction stages, or in accordance with the nature of the risk

(Zhi, 1995). Many approaches have been suggested in the literature for classifying risk in developing countries.

Santoso, Ogunlana and Minato (2003), classified risk factors in high rise building construction in Jakarta-Indonesia into nine main groups as follows: physical; personal; technical; safety-accident; construction design causes; political and regulation; financial; contractual; and environmental regulation causes. Personal and technical categories are further broken down into several sub-categories. 'Personal’ includes: technician and labour; subcontractor; staff and foreman; engineer; consultant; and client. 'Technical' comprises: material; equipment; technique; construction process; construction site; and ground conditions.

Long, Ogunlana, Quang and Lam (2004), in their study identified the problems in large construction projects in Vietnam. They classified risks into seven major groups. These are; Financier, Owner, Contractor, Consultant, project attributes, Coordination and Environment. Faridi and EI-Sayegh (2006) classified risk factors causing delay in the UAE construction industry into eight groups: contractor; consultant/designer; owner; financial; planning and scheduling; contractual relationship; government regulations; and unforeseen conditions. Lo, Fung and Tung (2006), classified causes of delay in Hong Kong construction industry into seven categories: client, engineer, contractor, human behaviour, project and resource related as well as external factors. Al-Kharashi and Skitmore (2008) in their study of identifying the critical problems of delays in the Saudi Arabian public construction sector classified risks into six major areas. These are; labour, contract/relationship, consultant, client and materials-related causes. El-Razek, Bassioni and Mobarak (2008), in their study of determining the main causes of risk in the Egyptian construction industry, classified risk as contractor, consultant and owners related.

According to Zou, Zhang and Wang (2007), there are many methods to classify the risks associated with construction projects and the rationale for choosing a method must serve the purpose of the research.

However, Fang, Li, Fong and Shen (2004) reported that because of the differences in social and economic systems, as well as the differences in historical and cultural backgrounds, contractors are likely to encounter different risks in different countries. Several researchers have identified critical risk factors in different construction industries in developing countries. In this research, extensive literature review was carried out to identify significant risk factors affecting performance in the construction sector in some developing countries as shown in Table 3.2.

Table 3.2: Significant risk factors affecting construction project performance in developing countries

Country	Reference	Risk factors influencing construction project performance
China	*Fang et al (2004)*	• Capital return difficulty • Owner's delay payment • Unfairness In tendering • Local protectionism • Owner's unreasonable upfront capital demand • Owners' unreasonably tight project duration • Difficulty In claiming Indemnity • Owner's Improper Intervention In construction phase • Subcontractors poor management • Low efficiency of construction administration departments, and late approval by relevant departments.
Ghana	*Frimpong, Oluwoye and Crawfod (2003)*	• Monthly payment difficulties from agencies • Poor contract management • Material procurement • Inflation • Contractors financial difficulties • Escalation of material prices • Cash flow during construction • Planning and scheduling deficiencies • Bad weather • Deficiencies in cost estimates prepared.
		• Inadequate resources due to contractor / lack of capital • Unforeseen ground conditions • Exceptionally low bids • Inexperienced contractor

Hong Kong	*Lo et al. (2006)*	• Works in conflict with existing utilities • Poor site management and supervision by consultant • Unrealistic contract duration Imposed by clients • Environmental restriction • Slow coordination and seeking of approval from concerned authorities • Variation / changes of scope.
Jordan	*Odeh and Battanineh (2002)*	• Owner Interference • Inadequate contractor experience • Financing and payments of completed work • Low productivity of labour • Slow decision-making by owners • Improper planning • Difficulties of Subcontractors • Poor site management • Improper construction methods • Mistakes during construction
Kuwait	*Nabil and Saied Kartam (2001)*	• Financial failure • Delayed payment on contract • Labour, material and equipment availability • Defective design • Coordination with subcontractors • Low productivity of labour and equipment • Contractor incompetence • Actual quantity of work • Poor quality of work • Inaccuracy of project programme
Lebanon	*Mezher and Tawil (1998)*	• Cash problems during construction • Schedule of subcontractors • Permits from municipality • Design changes by owner • Owner's slow decisions • Slow preparation and approval of shop drawings • Preparation of scheduling work • Lack of personnel training and management support • Unavailability of professional construction management • Difficulty In coordination between different parties

Libya	*El-Kmeshi (2006)*	• Plenty of additional works and modifications • Non adherence to follow suitable criteria for choosing the parties to the project • Delays In paying invoices and dues • Little incentive for workers in the owner's firm • Shorter period specified for completion • Frequently issued laws and regulations • Administrative routines.
Nigeria	*Ayodeji and Odeyinka (2006)*	• Contractors' financial difficulties • Clients' cash flow problem • Architects Incomplete drawing • Subcontractors' slow mobilization • Equipment breakdown and maintenance problems • Suppliers late delivery of ordered materials • Incomplete structure drawings; • Contractors' planning and scheduling problems • Price escalation • Subcontractors' financial difficulties. •
Saudi Arabia	*Al-Kalil and Al-Ghafly (1999)*	• Cash flow problems faced by the contractors. • Difficulties in financing the project by the contractor. • Difficulties in obtaining work permits • "Lowest bid wins" system • Delay in progress payments by the owner • Effects of subsurface conditions • Poor qualifications of the contractor's technical staff • Changes in the scope of the project • Ineffective planning and scheduling of the project by the contractor • Shortages of skilled, semi-skilled, and unskilled labour.

Thailand	*Ogunlana et al. (1996)*	• Shortages of construction materials • Shortages of labour • Incomplete drawings (designer); • Material management problems (contractor) • Deficiencies in contractors organization • Slow response (design) • Coordination deficiencies (contractor) • Planning and scheduling problems (contractor) • Insufficient equipment.
Turkey	*Arditi, Akan and Gurdamar (1985)*	• Difficulties in obtaining construction materials • Contractor difficulties in receiving monthly payments from public agencies • Contractors financial difficulties • Deficiencies in contractors organization • Deficiencies in public agencies' organization • Shortages of skilled labour • Large quantities of extra work • Shortage of technical personnel • Delays in design work • Deficiencies in planning and scheduling.
United Arab Emirate (UAE)	*El-Sayegh (2008)*	• Inflation and sudden changes In price • Owner's unreasonably Imposed tight schedule • Subcontractors poor performance and management • Delay of material supply by suppliers • Change of design required by owners • Owners improper intervention during construction • Shortage of manpower supply and availability • Delays In approvals • Lack or departure of qualified staff • Shortages of material supply and availability.

3.4 The Performance of the Nigerian Building Construction Industry

The construction industry, like in most developing countries is a leading driver of economic development. This is because every other sector largely depends on its products or services in order to fully operate (Oladinrin, Ogunsemi and Aje, 2012). The construction industry in Nigeria is an important industry which impacts positively on the national economy contributing 3.12% to the national economic growth as estimated in the rebased nominal GDP of 2013 (NBS, 2014). The growth of the construction industry is rising at a steady rate and is predicted alongside Indian construction industry to enjoy higher growth rate than china between 2009 and 2020 in terms of construction output (GCP, 2009). In Nigeria, the construction industry is typically dominated by small and medium sized local contractors who are mainly involved in private residential projects (Bashir, Suresh, Proverbs and Gameson, 2010). These small and medium sized local contractors are usually grouped as informal or unorganised sector of the industry (Dantata, 2008). This group as noted by Dantata (2008) comprises simple residential building projects built by private clients constructed through the effort of hired artisans and labour and in some cases, the owner supervises the construction directly, with the government not having any direct influence on the sector.

However, the major contractors, which are referred to as the organised sector (Dantata, 2008) comprises established contractors who are legally registered to carry out construction projects and they are usually made up of highly skilled workers, both expatriate and local labourers. These companies operate under a set of given rules and regulations of the country.

Similar to other Sub Saharan African (SSA) countries, the Nigerian construction industry is faced with enormous challenges which are constantly mitigating the development of infrastructure and the growth of the sector (Oluwakiyesi, 2011). The industry has been performing far below standards. This is basically because it is beset with many problems.

The general situation observed currently in building construction projects in Nigeria is that the output of a building construction industry is usually characterised by poor quality work, cost and time overruns (Oyewobi et al, 2011). These characteristics originate because a number of risk factors have not been properly taken into consideration in the project planning and implementation stage. These factors include but are not limited to: poor project definition during project planning, incomplete project designs at the design stage, unethical behaviours in the form of fraudulent practices, giving and taking kickbacks, undue delay of processes due to bureaucracy, delays from suppliers and poor site management (Thompson and Perry, 1992; Smith et al, 2006). These risks are usually ignored or handled in an arbitrary ways, which results to failures, expensive delays, litigation, and even bankruptcy (Mills, 2001).

Consequently, from the reports of Olusegun and Michael (2011), there are about 4000 uncompleted projects belonging to the Federal Republic of Nigeria with an estimated cost of almost £1billion. This will take 30 years to complete at the present execution capacity of the government. The failure to achieve targeted time, budgeted cost and specified quality result in various unexpected negative effects on building construction projects and thereby, has an appalling effect on the construction sector in particular to the national economy as a whole (Olusegun and Micheal, 2011). Cost and time overruns have become a cankerworm within the Nigeria construction industry today as well as lack of good quality end product, which do not provide many of the clients' value for money. Construction projects in Nigeria are known for overshooting their initial cost budget, which invariably means it is out of initial time schedule (Ogunsemi and Aje, 2005).

Since most building construction project is subjects to risk, risk management is an important part of the decision-making process in construction industry - as it determines the success or failure of construction projects (Abujnah and Eaton, 2010). Good decisions are made against a predetermined set of objectives based on knowledge, data, and information; whereas decisions that are made without a logical assessment of project-specific criteria may lead to difficulties in project delivery (Abujnah and Eaton, 2010). As a result, risk and uncertainty can potentially have damaging consequences for all building projects. The ineffective handling of risks can be damaging not only to the contractor, but also to the project as a whole. Risk can affect productivity, performance, quality, and the budget of a project. Risk sometimes cannot be eliminated, but it can be minimized, transferred or retained (Smith, et al., 2006).

3.5 Classification of Risk to General Sources

Numerous risk factors affect construction projects and could come from a variety of different sources (See section 3.3). These risks span a very broad spectrum, ranging from those risks that are perceived but are virtually unimaginable, with no historical precedence, to those risks that are well documented and fully analysed (Wirba et al., 1996). Therefore, risk classification is an essential step in the risk management process, as it aims to categorize the various risks (Tah and Carr, 2001). Many approaches have been suggested in the literature for classifying risks into groups to link these risks to their sources and hence improve the risk identification process (see section 3.3.1). For instance, According to Zhi (1995) the risk factors for construction projects are classified into four major groups or levels. Namely: nation/region; construction industry; company; and project. Zhi further broke down each group to a set of subgroups which accommodate a number of risk factors as shown in Figure 3.5.

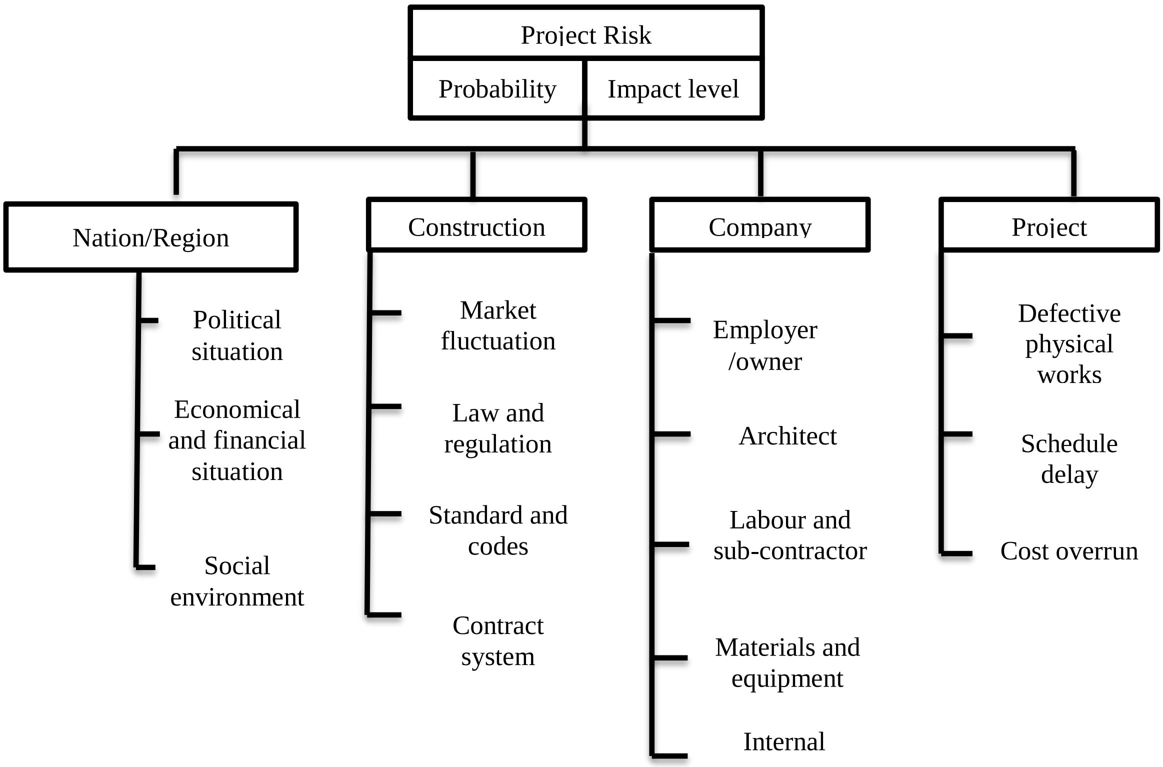


Figure 3.5: Risk identification hierarchy for construction projects

Source: Zhi (1995)

In viewing the previous categories that have been used to classify construction risks to a number of sources or group-related risks, the literature showed irregularity in these categories. In other words, there is inconsistency between risk management researchers in grouping risk factors. Therefore, a risk breakdown structure (RBS) will be developed in the subsequent section.

3.6 Classification of Risks into Internal and External Sources

A fundamental approach based on the classification of risk sources into external and internal factors for developing a risk breakdown structure suggests that external risks are those that originate from areas beyond the range of organization control, while internal risks are those that an organization's management can directly control and influence (Kiser and Cantrell, 2006). Further segmentation might suggest that external risks are related to economic, physical, political, and technological features. Internal risks include local risks related to an individual work package or category, and global risks that cannot be associated with any particular work package (Tah and Carr, 2001).

According to Hillson (2003), an advanced version of this concept is presented by the Universal Risk Project approach developed by the Risk management Specific Interest Group of the Project management Institute (PMI Risk SIG) and the Risk Management Working Group of the International Council on Systems Engineering (INCOSE RMWG). This method is designed as a guidance tool for managers to develop a list of "universal risk areas" that can be applied to any type of project or operation in any industry. Although this hierarchical list is not complete or comprehensive, it provides an overall review of potential risks that are categorized into three major areas:

1. The management risk, which includes risk that can be controlled by the organization and which are related to various aspects to project management, system management and organizational management
2. The external risk, which represents risk that originate from factors that are beyond the control of the organization, such as actions taken by exterior stakeholders, or climate, demography and market occurrences.
3. The technology risk, which refers to risk that are inherent to the technology and processes used in the project, product, system or analysis (Hall and Hullet, 2002).

Numerous authors also have broken down construction risks into internal and external risks. For instance, Tah and Carr, (2001) used a hierarchical risk-breakdown structure to classify risks into those that are related to the management of internal sources and those that are prevalent in the external environment. They claimed that external risks are relatively uncontrollable, and internal risks are those, which are relatively controllable and vary between projects. The internal risks are further broken down into local and global risks. The local risks are those related to individual work packages or categories within a project, whilst the others are global to an individual project and cannot be associated with any particular work package. The hierarchical representation is shown in Figure 3.6.

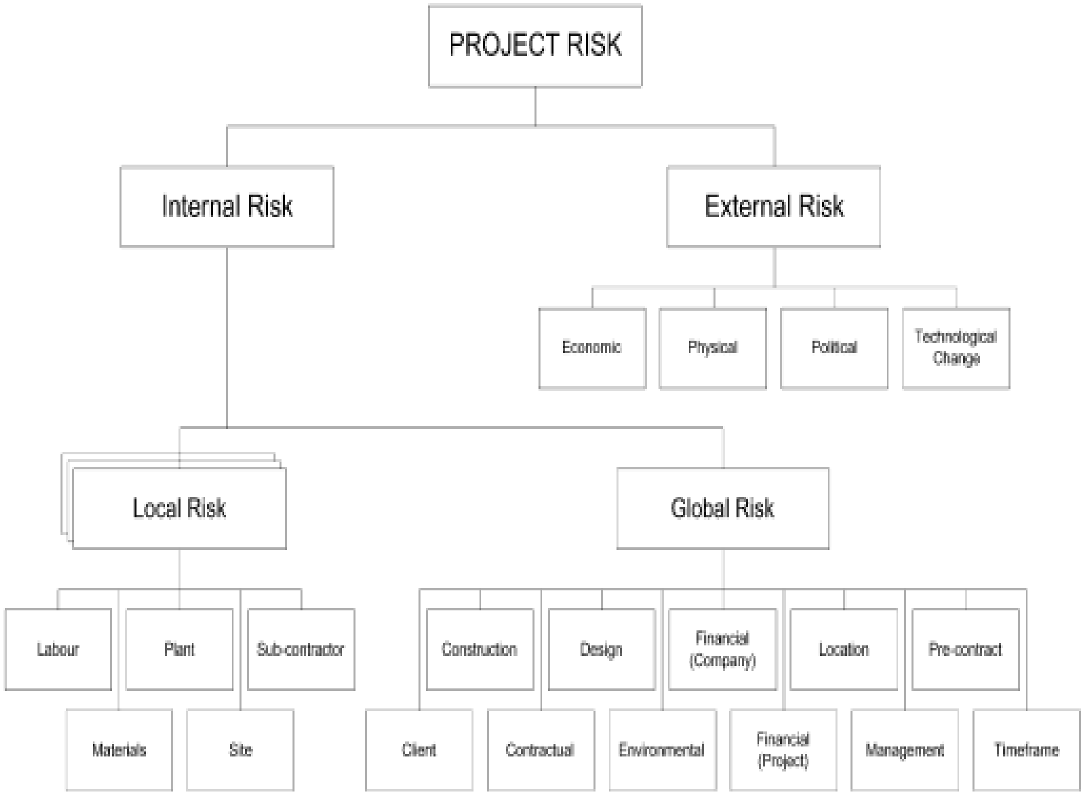
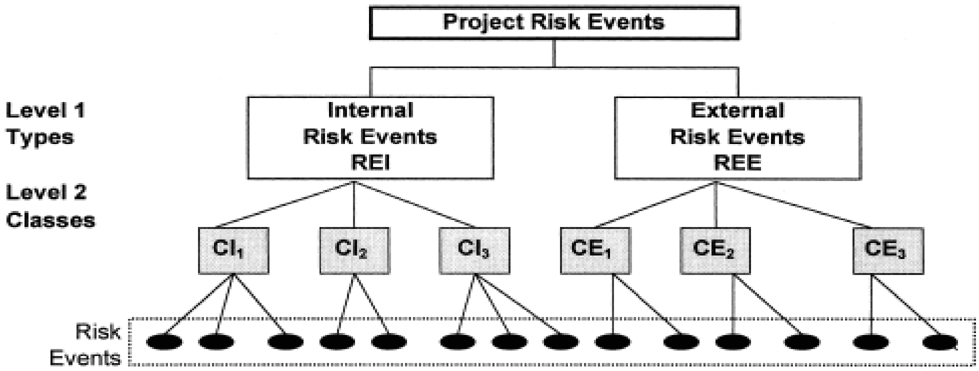


Figure 3.6: The hierarchical risk breakdown structure
Source: Tah and Carr (2001)

Aleshin (2001) classified risk factors by establishing a cause and effect connection between risk events. Risk classification according to cause and effect connections is carried out along the hierarchical system which is illustrated in Figure 3.7. According to the hierarchical system, the classified set of objects is first divided into types based on certain chosen characteristics (internal risks and external risks). Internal risks initiated inside the project while external risks originated due to the project environment. Then each type is divided into classes according to the predetermined characteristics.

Similarly, each class is divided into groups and the groups are further split into smaller sub groups.



$re_i \in RE$

Where:

CI_1 - Client's mistakes on the phase of Tender Documentation Development;

CI_2 – Not performing of duties imposed by the Contract on the Client and the Engineer.;

CI_3 - Additional requirements of Local Authorities and Municipal Services under the construction in progress.;

$\mathbf{REI = CI_1 \cup CI_2 \cup CI_3}$ and $\mathbf{CI_1 \cap CI_2 \cap CI_3 = \varnothing}$

$\mathbf{card\ (REI) = card\ (CI_1) + card\ (CI_2) + card\ (CI_3)}$

CE_1 - Actions of the third parties;

CE_2 - Unforeseen circumstances;

CE_3 - Weather conditions;

$\mathbf{REE = CE_1 \cup CE_2 \cup CE_3}$ and $\mathbf{CE_1 \cap CE_2 \cap CE_3 = \varnothing}$

$\mathbf{card\ (REE) = card\ (CE_1) + card\ (CE_2) + card\ (CE_3)}$

Figure 3.7: Steps to risk classification
Source: Aleshin (2001)

Wang and Chou (2003) argued that the sources of risk in the Taiwan highway projects can be divided into two types: external and internal. The external type includes: the political and economic factors; the natural environmental factors; and the third party factors. The internal type includes: the owner; design; consultant and supervisor factors; the contractor factors; the labour factors; the subcontractor factors; and the material and equipment factors.

Fang et al. (2004) claimed that according to sources of risk events, risks in the Chinese construction market can be divided into external and internal risk events as shown in Figure 3.8. External risks refer to those which are related to factors such as government policies or weather, and which are beyond the direct control of project managerial personnel. Under this classification are several risk events. Internal risks refer to those that will produce a direct influence to a specific project. According to risk sources, internal project risks are further classified as: pre-project phase; design unit; supervisory unit; subcontractor; supplier; owner's unit; construction management; post-project phase; and others.

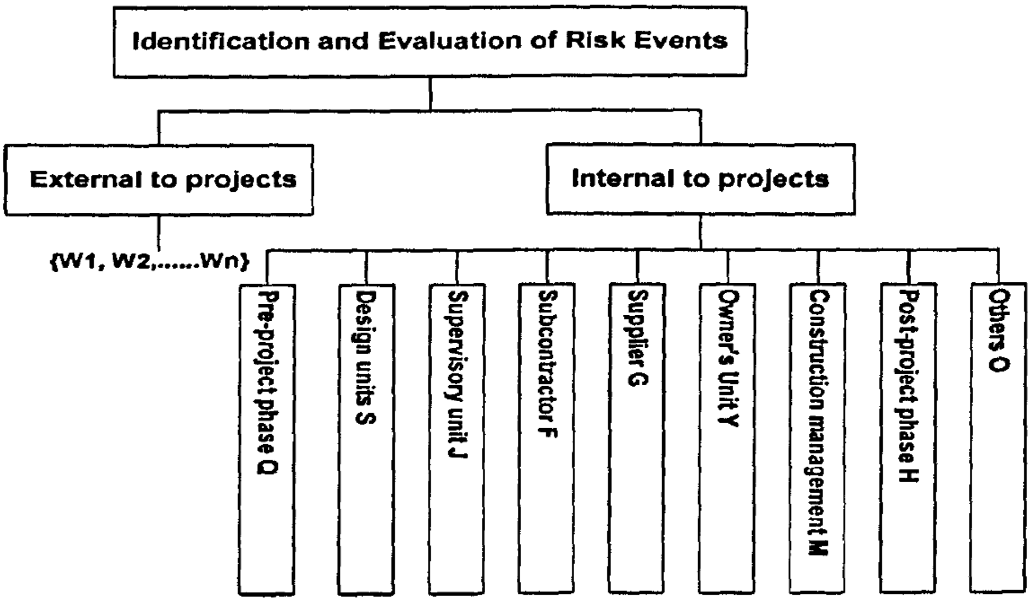


Figure 3.8: Classification of risk events
Source: Fang et al, 2004

EI-Sayegh (2008) developed a risk breakdown structure to organize the different categories of risks that affect the construction industry in the UAE. The risk breakdown structure of Figure 3.9 shows the risk groups, risk categories, and risk events at the lowest level. Project risks are divided into two groups, according to their source, either internal or external. Internal risks are those that are project related and usually fall under the control of the project management team. External risks are those risks that are beyond the control of the project management team.

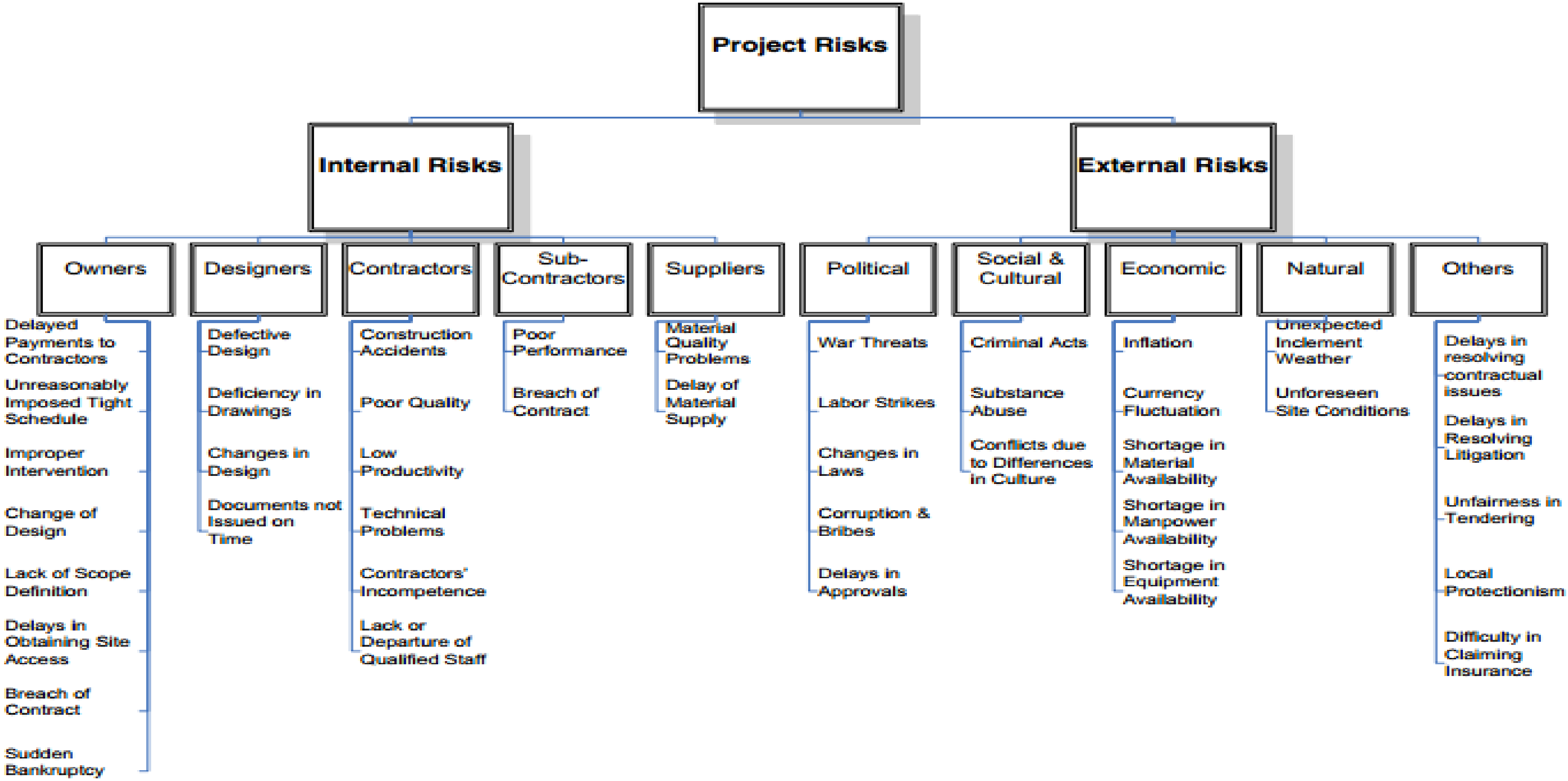


Figure 3.9: Risk breakdown structure
Source: El-Sayegh (2008)

Consequently, an additional RBS scheme is presented by Tchankova (2002). Using this method, risk sources are displayed in a hierarchical tree that represents the various environmental areas in which the risks originated. These include physical, social, political, operational, economic, legal and cognitive environments. Each of these areas is further divided into sub-areas as specifically required for the purposes of the project or the organization.

A different approach to the representation of all project risks is based on project lifecycle. Cohen and Palmer (2004) suggested classifying any potential risk into one of four stages in a typical project lifecycle: the feasibility stage, which is the initial stage of a project; the planning and design stage, in which the basic parameters for executing the project are established; the construction stage, which is targeted to actually execute the work; and the start-up and turnover stage, which finalizes the project. Das and Teng (1999) presented a similar approach within a strategic alliance process that consists of partner selection, structuring, operation, and performance evaluation.

3.7 Developing a Risk Breakdown Structure

Breakdown is a technique by which the project is divided and subdivided for management and control purposes (Turner, 2014). The Risk Breakdown Structure (RBS) is seen as a hierarchical structure of potential risk sources, which can be an invaluable aid to understanding the risks faced by a project, acting as a framework to structure and guide the risk management process, in the same way that the WBS has been the project manager's greatest tool in planning activities, because it scopes and defines the work (Hillson, 2002a). The easiest way to understand an RBS is by drawing the analogy to the Work Breakdown Structure (WBS). According to Wysocki (2009), the WBS is a "*hierarchical description of all work that must be done to complete the project in the project overview statement*". Consequently, Hillson (2002a) defines RBS as a "*source-oriented grouping of project risks that organizes and defines the total risk exposure of the project. Each descending level represents an increasingly detailed definition of sources of risk to the project*". Consequently, Holzman and spiegler, (2011), describes the RBS as a hierarchical structure that represents the overall project and organizational risk factors and events organized by group and category. According to Turner (2014), there are several reasons for using a breakdown structure. These are;

- Better control: one of the dangers in planning is to develop the work definitions at a single detailed level. Developing the definition in a structure way ensures better result.
- Coherent delegation: the parcelling of work in a breakdown structure is natural, because it is aimed at achieving a product. Responsibilities are assigned to individual parties for each product.
- Levels of estimation and control: the lowest level of breakdown appropriate for estimating and control depends on;
  - The size, type and duration of the project
  - The purpose for which the estimates will be used
  - The current stage in the project management life cycle
  - The requirement for effective control
- Containment of risk: this depends on the uncertainty introduced by the risk and the need to contain the risk.

The risk management process aims to identify and assess risk in order to enable the risk to be understood clearly and managed effectively (Hillson, 2002a). The key step linking identification/assessment of risks with the management is understands. This is however, the area where project managers or risk practitioners get least help from current guidelines or practice standards (Hillson, 2002a). There are many techniques for risk identification (See section 2.5.2). These risk identification techniques seeks to produce an unstructured list of risks that often does not directly assist project managers in knowing where to focus risk management attention (Hillson, 2002a).

In addition, Hillson (2002a) reports that qualitative assessment can help to prioritise identified risk by estimating likelihood and consequences, exposing the most significant risk; however, this deals with risk one at a time and does not consider possible patterns of risk exposure, and so also provide and overall understanding of risk faced by the project in a whole. The main advantage of the risk breakdown structure is its ability to display a comprehensive hierarchical scheme that can be reduced or broadened, in depth or in breadth, to meet varying needs. The items in the risk breakdown structure are exhaustive and mutually exclusive so that each one of the identified risks can be assigned only to a single item and cannot be allocated to more than one item. Furthermore, the risk breakdown structure provides a visual illustration of overall risk exposure, thereby enabling the detection of specific risk items, and facilitates locating risk areas in which the organization is exposed to severe damage, hence requiring special attention by the organization management (Hillson, 2002a; Hillson, 2003).

Building construction is a risky industry with uncertainties due to many external and internal factors that influence the construction process. The review of classification systems in the construction industry revealed that there is no explicit evidence that establishes the relationship between the main sources and the factors contributing to them. Hence, developing a Risk Breakdown Structure (RBS) to accommodate risk factors that affect building construction projects in developing countries is needed.

Enshassi and Mosa (2008) suggested that risk factors that affect building construction projects in developing countries can be classified as physical, environmental, design, logistics, financial, legal, construction, political and management. Therefore, this classification will be adopted, with a minor modification, as illustrated in figure 3.10.

In examining the validity of the derived Risk Breakdown Structure (RBS) categories, it is obvious that it accommodates all risk groups presented in the literature. Therefore, risk factors assembled (see section 3.3.1) will be linked to their sources (categories) based on individual and group discussions with a number of group experts (discussed in chapter five) and knowledge pertaining to this subject.

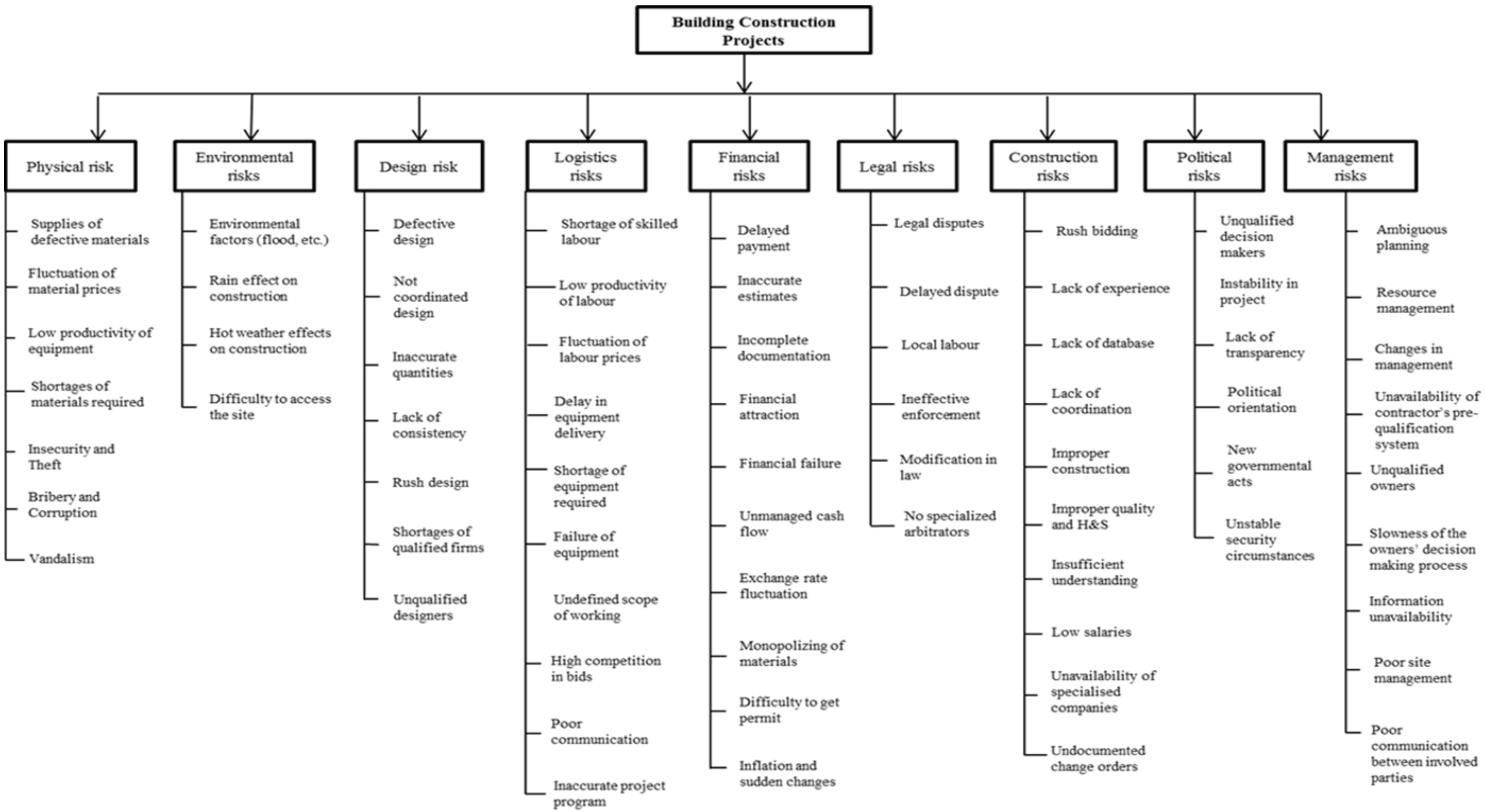


Figure 3.10: Classification of risk factors that affect building construction projects in developing countries (Developed by researcher)

3.8 Tools and Techniques for Qualitative Risk Analysis

The analysis of risk is a complex subject shrouded in uncertainty and vagueness. The complexity arises from the subjective opinion, which is influenced by the respondent's view of risk based on knowledge from past experience, and imprecise non-numeric quantification of likelihood and impact (Tah and Carr, 2000). Therefore, in qualitative risk analysis, the probability of occurrence and impact of each identified risk is normally assessed using agreed scales such as: very low, low, moderate, high, and very-high (PMBOK, 2000). The aim of the qualitative risk analysis process is to prioritize risks according to their effect on project objectives.

3.8.1 Risk probability or Impact

Quite a number of researchers view risk events as being associated with either probability or impact and used the relative importance index as a measure of the risk significance (Assaf, 1995; Mezher and Tawil, 1998; Odeh and Battaineh, 2002; Faridi and EI-Sayegh, 2006; Muhwezi et al, 2014) and compute the relative importance index using the following equation:

Relative Importance Index, $RII = \frac{\Sigma W}{A * N}\ (0 \leq RII\ \leq 1) \ldots \ldots \ldots 1$

Where:

W – Is the weight given to each factor.

A – Is the highest weight

N – Is the total number of respondents.

Carter et al. (1995) claimed that this approach does not provide a convenient means to evaluate or compare risks among themselves, hence considering only probability or impact is meaningless.

3.8.2 Risk Probability and Impact

Risk management researchers consider risk factors as being coupled with both probability and impact (Kaming et al., 1997; AI-Khalil and Al-Ghafly, 1999; EI-Sayegh, 2008, etc) and argue that risk can be assessed as a result of multiplication of probability and impact.

$$R = P \times Q \ldots \ldots (2)$$

Where:

R= the degree of risk

P= Probability of risk occurrence

Q= the consequences or perceived impact of risk

Williams (1996) opposes that multiplying the probability and impact to measure the 'expected' risk is misleading, since the correct treatment requires both dimensions. Nevertheless, this approach is prone to generate too many risks as it produces two lists of risk factors hence; it is hard to evaluate the most important ones. However, many researchers (Santoso et al, 2003; Andi, 2006; Odeyinka, 2006) have adopted this approach.

3.8.3 Probability-Impact (P-I) Matrix

A risk acceptability matrix is constructed based on a simple multiplication of the scale values assigned to probability and impact. These two dimensions are combined to determine whether a risk is considered low, moderate, or high. The P-I matrix can be developed using ordinal or numerical scales; linear or non-linear (PMBOK, 2000).

Several organizations have used this system with different combinations of probability and impact. Carter et al. (1995) used three ordinal point scales for probability and impact and suggested that risk likelihood and impact should be qualitatively assessed as; low, medium, high. Also, he claimed that the degree of risk exposure can be evaluated as: unacceptable, critical, significant and minor risk as illustrated in Figure 3.11.

Probability / ***Impact***	**Low**	**Medium**	**High**
High	Critical	Unacceptable	Unacceptable
Medium	Significant	Critical	Unacceptable
Low	Minor	Significant	Critical

Figure 3.11: Classes vs qualified risk impact and probability
Source: Carter et al (1995)

Consequently, CIRIA (1996) suggested that risk likelihood may be gauged as frequent, probable, occasional, remote, and improbable and risk consequences as catastrophic, critical, serious, marginal, and negligible. CIRIA also, suggested five linear scales for likelihood and consequences (0, 1, 2, 3, and 4) as shown in Figure 3.12. The CIRIA approach revealed that risk acceptability can be categorized as unacceptable, undesirable, acceptable, and negligible as illustrated in Figure 3.13.

RISK IMPORTANCE					
Consequences / ***Likelihood***	**Catastrophic (4)**	**Critical (3)**	**Serious (2)**	**Marginal (1)**	**Negligible (0)**
Frequent (4)	16	12	8	4	0
Probable (3)	12	9	6	3	0
Occasionally (2)	8	6	4	2	0
Rarely (1)	4	3	2	1	0
Improbable (0)	0	0	0	0	0

Figure 3.12: Assessment of risk importance
Source: CIRIA (1996)

RISK ACCEPTABILITY					
Consequences* / *Likelihood	**Catastrophic**	**Critical**	**Serious**	**Marginal**	**Negligible**
Frequent	Unacceptable	Unacceptable	Unacceptable	Undesirable	Undesirable
Probable	Unacceptable	Unacceptable	Undesirable	Undesirable	Acceptable
Occasionally	Unacceptable	Undesirable	Undesirable	Acceptable	Acceptable
Rarely	Undesirable	Undesirable	Acceptable	Acceptable	Negligible
Improbable	Undesirable	Acceptable	Acceptable	Negligible	Negligible

Figure 3.13: Assessment of risk acceptability
Source: CIRIA (1996)

PRAM (2004) used five linear scales for risk probability (0.1, 0.3, 0.5, 0.7 and 0.9) and five nonlinear scales for risk impact (0.05, 0.1, 0.2, 0.4, and 0.8) as illustrated in Figure 3.14. PRAM argued that it is possible to categorize risk severity as High, Medium, or Low, using threshold values of P-I score. High risks might be defined as those with P-I score greater than 0.2, Medium risks are those with P-I score between 0.1 and 0.2, with low risks having scores less than 0.1.

Probability* / *Impact	**Very Low (0.1)**	**Low (0.3)**	**Medium (0.5)**	**High (0.7)**	**Very High (0.9)**
Very Low (0.05)	0.005	0.015	0.025	0.035	0.045
Low (0.1)	0.01	0.03	0.05	0.07	0.09
Medium (0.2)	0.02	0.06	0.10	0.14	0.18
High (0.4)	0.04	0.12	0.20	0.28	0.36
Very High (0.8)	0.08	0.24	0.40	0.56	0.72

Figure 3.14: Probability-Impact scores
Source: PRAM (2004)

PMBOK (2000) utilized the same probability and impact scales given by PRAM (2004). However, it proposed different threshold values for risk acceptability as shown in

Figure 3.15. In addition, PMBOK (2000) reports that organizations must determine which combinations of probability and impact result in risk being classified as high (red condition), moderate (yellow condition), and low risk (green condition).

Impact / ***Probability***	**Very Low (0.05)**	**Low (0.1)**	**Medium (0.2)**	**High (0.4)**	**Very High (0.8)**
Very High (0.9)	0.05	0.09	0.18	0.36	0.72
High (0.7)	0.04	0.07	0.14	0.28	0.56
Medium (0.5)	0.03	0.05	0.10	0.20	0.40
Low (0.3)	0.02	0.03	0.06	0.12	0.24
Very Low (0.1)	0.01	0.01	0.02	0.04	0.80

Figure 3.15: Probability-Impact Matrix
Source: PMBOK (2000)

Dallas (2006) argued that the use of the three point scale and the five point scale matrices suffer from the disadvantage of central tendency drift in each of the ranges. This encourages avoidance during assessment by picking the middle in the range. A better approach would be a 4-point or a 6-point scale which forces the assessor to choose an impact or likelihood on either side of the mid-point.

Dallas further reports that another drawback with the above system is that it does not differentiate between those risks that are highly likely to occur but will have low impact and those risks that are very unlikely to occur but would have disastrous impact if they did. However, the management strategy should pay more attention to the later than the former.

3.8.4 The Skewed Matrix

The Institution of Civil Engineers ICE (2005) in its publication 'Risk Analysis and Management for Projects' (RAMP) devised a risk acceptability matrix to measure the significance of risks. RAMP also, stated that risk likelihood may be measured as: highly likely; likely; fairly likely; unlikely; very unlikely; and extremely unlikely and risk consequences as: disastrous; severe; substantial; marginal; and negligible.

The ICE (2005), suggested six nonlinear scales for likelihood (1, 2, 4,8,12 and 16), and five nonlinear scales for consequences (1,3,20,100 and 1000) as illustrated in Figure 3.16, and claimed that the risk acceptability can be classified as: intolerable; undesirable; acceptable; and negligible. Intolerable risks might be defined as those with P-I score over 1000, undesirable risks are those with P-I score between 101 and 1000, acceptable risks with P-I score between 21-100, with negligible risks having scores up to 20 as shown Table 3.3.

Consequences / ***Likelihood***	**Disastrous (1000)**	**Severe (100)**	**Substantial (20)**	**Marginal (3)**	**Negligible (1)**
Highly likely (16)	16000	1600	320	48	16
Likely (12)	12000	1200	240	36	12
Fairly likely (8)	8000	800	160	24	8
Unlikely (4)	4000	400	80	12	4
Very Unlikely (2)	2000	200	40	6	2
Extremely unlikely (1)	1000	100	20	3	1

Figure 3.16: Acceptance of risk
Source: RAMP (2005)

Table 3.3: Key to acceptance of risk
Source: RAMP (2005)

POINTS	**CATEGORY**	**ACTION REQUIRED**
Over 1000	Intolerable	Must eliminate or transfer risk
101-1000	Undesirable	Attempt to avoid, reduce or transfer risk
21-100	Acceptable	Retain and manage risk
Up to 20	Negligible	Can be ignored

Dallas (2006) argued that the use of a skewed matrix, which rates impact higher than likelihood overcomes the scale-unity problem since, in the skewed matrix, the Likelihood is measured on a scale of 1-16, whereas the impact is rated on a scale of 1-1000. Therefore, a risk which is highly likely to happen but of marginal impact will be rated at 16. However, if it is extremely unlikely but could have disastrous consequences, it will score 1000. Hence, the two cases of risk significance are distinguished.

3.9 Developing a Risk Acceptability Matrix

The risk acceptability matrices which have been devised by The Institution of Civil Engineers ICE (2005) in its publication 'Risk Analysis and Management for Projects' (RAMP) will be adopted with a minor modification to suit the nature and purpose of the study. Tah and Carr (2001) stated that a common language for describing risk likelihood and impact is necessary so as to achieve consistent quantification. These two dimensions are combined to determine whether risk is considered low, moderate or high. In order to achieve a consistent quantification, the terms used in this research to quantify risk likelihood are improbable, rarely, occasionally, probable and frequent. Also, the terms used to quantify risk impact are marginal, little, moderate, great and extreme.

PRAM (2004) declared that "to ensure consistency of assessment, the meanings of each scale point should be defined". Therefore, the terms, meanings, and measures chosen for the current work are given in Tables 3.4 and 3.5.

Table 3.4: Risk assessment table- Likelihood
(Developed by the researcher)

Description	***Scenario***	***Scale Value***
Frequent	Very frequent occurrence	5
Probable	Likely to occur regularly	4
Occasional	Quite often occurs	3
Rarely	Small likelihood but could well happen	2
Improbable	Unlikely but possible	1

Table 3.5: Risk assessment table- Impact
(Developed by the researcher)

Description	***Scenario***	***Scale Value***
Extreme	Project could not be sustained (e.g. bankruptcy)	5
Great	Serious threat on project	4
Moderate	Medium effect on project	3
Little	Small effect on project	2
Negligible	Trivial effect on project	1

The risk acceptability matrix (RAM) categorises the significance of risk as low risk (acceptable), medium risk (undesirable), and high risk (unacceptable) as illustrated in Figure 3.17 and provides threshold values to risk acceptability as shown in Table 3.6.

Impact / Likelihood	Extreme (5)	Great (4)	Moderate (3)	Little (2)	Marginal (1)
Frequent (5)	**R3**	**R3**	**R3**	**R2**	**R1**
Probable (4)	**R3**	**R3**	**R2**	**R2**	**R1**
Occasionally (3)	**R3**	**R3**	**R2**	**R2**	**R1**
Rarely (2)	**R3**	**R2**	**R2**	**R1**	**R1**
Improbable (1)	**R3**	**R2**	**R1**	**R1**	**R1**

Figure 3.17: Risk Acceptability Matrix (RAM) – Categorisation
(Modified from RAMP).

Table 3.6: Key to acceptance of risk
(Developed by the researcher)

Rank	**RISK**	**CATEGORY**	**ACTION REQUIRED**
1 - 9	High risk (R3)	Unacceptable	Must eliminate or transfer risk
10 - 18	Medium Risk (R2)	Undesirable	Attempt to avoid, reduce or transfer risk
19-25	Low Risk (R1)	Acceptable	Retain and manage risk

The risk acceptability matrix recommends some actions which have to be taken to respond to risks based on their perceived significance or acceptability as illustrated in Table 3.5. The risk acceptability matrix prioritise the significance of risk factors according to their position on the risk matrix to 25 ranks, utilizing the difference in scales between likelihood of occurrence and impact as shown in Figure 3.18.

Impact / Likelihood	Extreme (5)	Great (4)	Moderate (3)	Little (2)	Marginal (1)
Frequent (5)	**(1)**	**(6)**	**(9)**	**(15)**	**(21)**
Probable (4)	**(2)**	**(7)**	**(11)**	**(16)**	**(22)**
Occasionally (3)	**(3)**	**(8)**	**(12)**	**(18)**	**(23)**
Rarely (2)	**(4)**	**(10)**	**(14)**	**(19)**	**(24)**
Improbable (1)	**(5)**	**(13)**	**(17)**	**(20)**	**(25)**

Figure 3.18: Risk Acceptability Matrix (RAM)-Prioritisation
(Modified from RAMP).

Clearly, the higher the mean value of the impact and likelihood of the risk factor, the more critical it is perceived by contractors, subcontractors and clients. These values were then used to rank the most critical risk factor affecting building construction projects using the risk acceptability matrix (RAM) as shown in Figure 3.18.

3.10 Chapter Summary

A critical review of literature on causes of poor construction project performance has been conducted in this chapter. The literature review identified the problems and provided definitions and key concepts. It showed that numerous researchers have given an extensive list of risk factors that affect construction projects generated from different sources. Previous studies revealed that there is no consensus in the identification of construction risk factors. That is probably because the construction industry of any country is unique and risk factors could come from many different sources. This chapter identified major risks factors in building construction projects in developing countries. Seventy nine (79) risk factors were identified through literature review and were classified into 9 groups as physical, environmental, design, logistics, financial, legal, construction, political and management risk. These risk factors have been adopted in this research and presented in Risk Breakdown Structure (RBS) in this chapter. Consequently, the Risk Acceptability Matrix (RAM) which categorises the significance of risk as low (acceptable), medium (undesirable) and high risk (unacceptable) is developed in this chapter. The Risk Acceptability Matrix (RAM) will be adopted for a Bayesian belief network (BBN) risk assessment in this research. Subsequently, a threshold values to risk acceptability is presented in this chapter which recommends some actions to be taken in order to respond to risks based on their perceived significance or acceptability. Empirical evidence is therefore required to assess each risk factor based on their likelihood of occurrence and impact on building construction projects in Nigeria using a five point scale. The next chapter covers details of the research methodology.

CHAPTER FOUR: RESEARCH METHODOLOGY

4.0 Chapter Introduction

This chapter describes the research methodology adopted for this study. The research methodology of a study directly impacts the strength and generalizability of the research (Yang, Wang and Su, 2006). This chapter discusses the procedure by which the research was conducted with a justification for the chosen approach. It addresses the research methods adopted to capture data required to achieve the research aim and objective. The mixed research method was used in this study to develop a risk management system for building construction projects in Nigeria.

4.1 Styles of Research

Saunders, Lewis and Thornhill (2009) describe **research** as "*something that people undertake in order to find out things in a systematic way thereby increasing their knowledge*". They consequently identified the characteristics of a good research which include: ensuring data are collected systematically, data are interpreted systematically and there is a clear purpose to find things out. There are different styles of research such as constructive, theoretical, empirical, nomothetic, idiographic, critical etc.

Ideas about research methodology are continuously evolving. In this respect, Saunders, Lewis and Thornhill (2007) have improved the 'research onion' model twice originally proposed by Kagioglou, Cooper, Aouad, Hink, Sexton and Sheath (1998). In the first instance, they added two more layers (concerned with 'research strategy', and 'time horizon and data approach') within the research process as shown in Figure 4.1 and made the second improvement in 2012, where they expanded the research onion to include a layer concerned with 'research choice' which covers thoughts about mono-methods, mixed-methods and multi-methods (Saunders, Lewis and Thornhill, 2012).

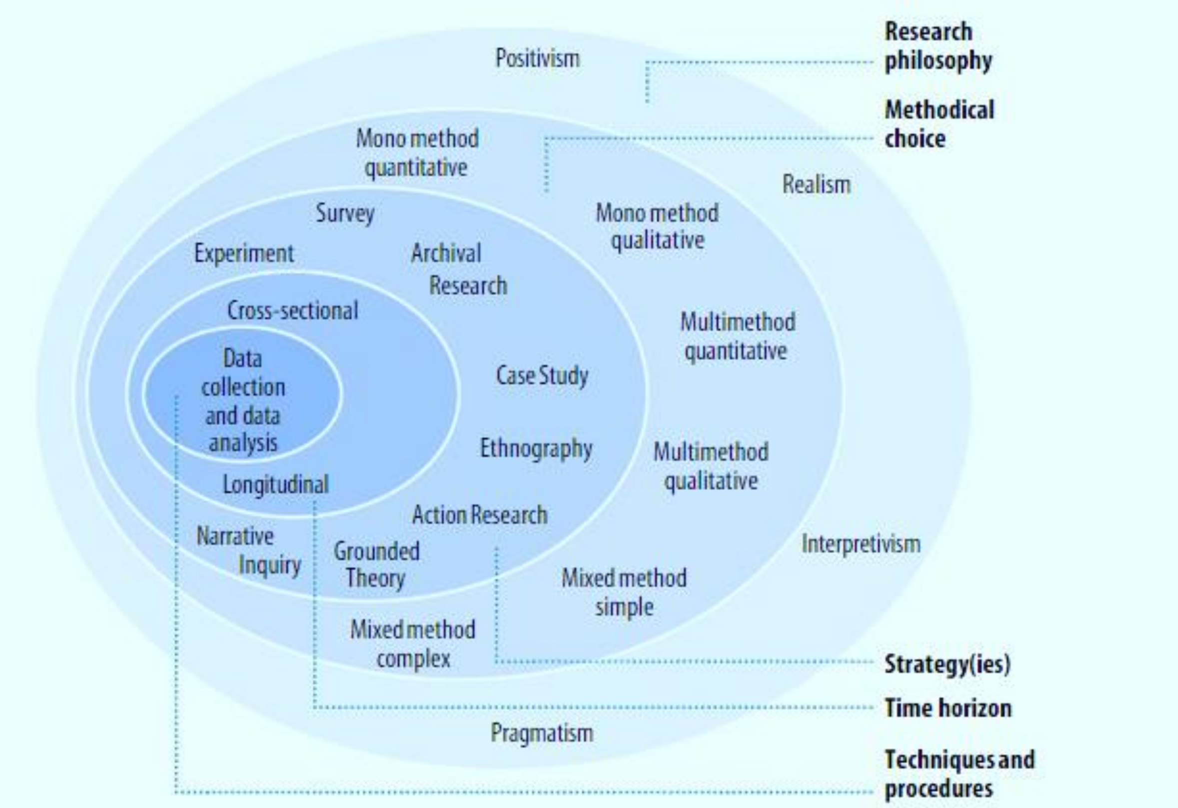


Figure 4.1: Research methodology process- The research 'Onion'
Source: Saunders et al (2012)

4.2 Research Methods, Research Methodology, Research Strategy, Philosophical Paradigm

According to Easterby et al (2012), methods are the instruments and processes for gathering research data, analysing it and drawing conclusion from it. A method is a systematic and orderly approach taken towards the collection and analysis of data so that information can be obtained from those data (Jankowicz, 2005). Consequently, the term methodology refers to the theory of how research should be undertaken (Saunders et al, 2012). Methodology is an explanation of why certain data is collected, what data is collected, from where the data is collected, when it is collected, how it was collected and how it was analysed (Collis and Hussey, 2003). Therefore, the research methodology should address four main issues: what data are needed, where the data are located, how data are obtained and how data are analysed (Leedy, 1997).

A research methodology may be implemented through several different research strategy which is also known as a research plan or designs, the plan for conducting a study, through translating the research methodology into specific research methods, the technique used to collect and analyse data (Maylor and Blackmon, 2005). Furthermore, a Philosophical paradigm which is sometimes referred to as a research paradigm is known as the philosophy of a particular research. A paradigm is a way of examining social phenomena from which particular understandings of these phenomena can be gained and explanations attempted (Saunders et al, 2012). The research paradigm/philosophy therefore, offers a framework, consisting of theories, methods and ways of defining data which explains the relationship between data and theory (Easterby-Smith, Thorpe and Jackson, 2012; Collis and Hussey, 2003).

Every research is conducted to answer one or more research questions and the research methodology structures the path for doing so. Meanwhile, the research philosophy is pivotal in portraying the researcher's standpoint against the research problem. Saunders et al (2009) portrays in form of an onion, an illustration of the relationship of research philosophies, strategies, approaches, and methods that could be undertaken by researchers based on the nature of their investigation (Figure 4.1). Besides, this logically sets out various stages of a research project in form of an onion where layers indicate inward levels of progression. However, this research adopts Saunders et al (2012) description of the different research terms as shown in Figure 4.1.

4.2.1 Philosophical Paradigm

Saunders et al. (2012) describes philosophy as the belief and thinking that an individual has about knowledge and how it is created and developed. Research philosophy describes the theory of research in a particular field and explains the assumptions that underlie the research approaches (Maylor and Blackmon, 2005). These assumptions mainly concern the nature of reality and how we can know reality.

According to Easterby et al (2012), there are at least three reasons why understandings of philosophical issues are very useful. First, it helps to clarify research designs. This does not only involve considering what kind of evidence is required and how it is to be gathered and interpreted, but also how this will provide good answers to the basic questions being investigated in the research. Second, knowledge of philosophy can help the researcher to recognise which design will work and which will not. It indicates the limitations of a particular approach. Third, it can help the researcher identify, and even create, designs that may be outside their past experience. It may also suggest how to adapt research designs according to constraints of different subject or knowledge structures. According to Holden and Lynch (2004), the concepts of philosophy have to be considered to match the research approach and underlying philosophy; these are ontology, epistemology and axiology.

4.2.1.1 Ontology

Ontology is concerned with the nature of reality-what is considered to exist and, just as importantly, what does not exist in the environment studied (Saunders et al, 2012: Maylor and Blackmon, 2005). It is the science or study of being and is often used synonymously with metaphysics, one of the oldest branches of philosophy (Holden and Lynch, 2004). Grix (2002) describes ontology as the starting point of all research, after which one's epistemological and methodological positions logically follow. There are two aspects of ontology, objectivism (also referred to as critical view, evaluatism, empiricism, logical positivism, and dualism) and constructivism (also referred to as subjectivism, interpretivism, absolutism, relativism, postpositivism, and constructionism) (Huglin, 2003). Furthermore, with the ontological assumption, it must be decided whether to consider the world as objective and external to the researcher, or socially constructed which is to only understand by examining the perception of the human factor (Collis and Hussey, 2003). The main difference between the two positions is usually based on how a researcher believes knowledge is created.

4.2.1.2 Epistemology

Epistemology is concerned with the study of knowledge and what we accept as being valid knowledge (Collis and Hussey, 2003). This involves an examination of the relationship between the researcher and that which is being researched. Epistemology (also referred to as postpositivism) is difficult sometimes to differentiate from ontology as they are both concerned with knowledge. The epistemological assumption can be separated into either positivistic or interpretivist paradigms (Collis and Hussey, 2003). However, Crotty (2003) identifies that in recent times, other stances have emerged such as feminism, critical inquiry etc.

4.2.1.3 Axiology

Axiology is the study of value (Vaishnavi and Kuechler, 2007). It is either the collective term for ethics and aesthetics philosophical field that depend crucially on notion or the foundation for these fields, and thus is similar to value theory and meta-ethics (Vaishnavi and Kuechler, 2007). Axiology is an objective format for measuring intangible attitudes and values. Moreover, axiology measures the level of development and the type of one's perceptual biases in one's thinking (Brown and Sally, 2007).

4.2.2 The Current Research Philosophical Paradigm

Knight and Ruddock (2009) reports that the most important consideration for researchers is the need to be aware of the influence of the methodology they choose and that they must also highlight their own philosophical preference. They also discussed the arguments presented by Richard Rorty (1931-2007) about the varying perspectives that exist about the world, and investigate the mediation between language and culture, concluding that knowledge is most probably relative to interests, and is largely fixed in cultures. This is an important point to acknowledge in respect of this particular research, since it is conducted in a multicultural environment, the data being collected in Nigeria where there are different languages, and the culture is different to that of the United Kingdom.

Reviews from the aforementioned philosophical standpoints, Marsh and Furlong (2010) refer to epistemology as the study of knowledge and justified belief. Epistemology can be outlined as exploring the possibility, limits, origin, structure, methods and truthfulness of knowledge along with methods that knowledge can be acquired, validated and applied (Delanty and Strydom, 2003). In epistemological term, the research is pragmatic in nature (Pierce, 1931). This is because there is flow of information throughout and iteration process. Hence, the dependency is on predictable artefacts gives the research an epistemology that is similar to that of natural science research (Vaishnavi and Kuechler, 2007). On the other hand, ontology is the study of the nature of reality. It distinguishes what is real from what is not. However, this research deals with alternative or multiple world states which differs from ontology that deals with a composite unit of analysis (Vaishnavi and Kuechler, 2007). Axiology is the study of value. The researcher takes a positivist stance and values creative manipulation and control of his environment.

4.3 Research Approach

Research approach primarily involves the assortment of research questions, the theoretical framework that has to be accepted and the assortment of suitable method which can either be primary or secondary research.

In research, there are two broad approaches of reasoning which can be named as "Deductive" and "Inductive".

i. Deductive (testing theory): This is much more a scientific research that entails the progress of a premise and a hypothesis and designs a research strategy to examine the hypothesis (Saunders, 2007). According to Robson (2002) as cited in Saunders (2007), there are five consecutive stages all the way through, which deductive research will advance;
   - Deduce the hypothesis from the theory
   - Articulate the hypothesis in functioning stipulations which recommends an association between the two precise concept and variable.
   - Test the functioning hypothesis
   - Examine the precise result of the investigation.
   - And if needed, adjust the theory to correspond to the findings

Consequently, Burney (2008) describes the deductive approach as a top-down approach, which can be seen in Figure 4.2.

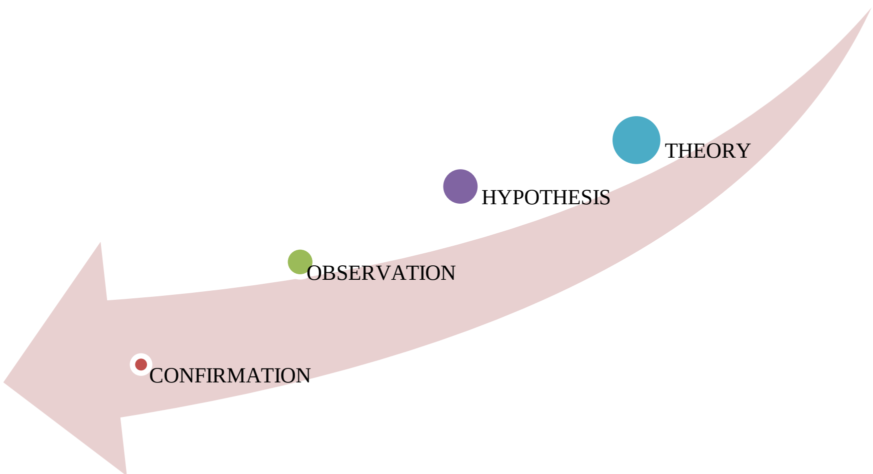


Figure 4.2: Deductive approach
Source: Burney (2008)

Some significant qualities of the deductive approach is that ideas needs to be done in a method that allows evidence to be calculated quantitatively and generalized statistically about regularities in human social behaviour, it is essential to select samples adequate for numerical size (Saunders et al, 2007).

ii. Inductive (building theory) - This involves a process whereby the researcher collects data and develops theory on the result of their data analysis. In using the inductive approach, the researcher is likely to be connected particularly with the background in which events were taking place like studying a little sample of topics rather than a great number as the deductive approach (Saunders, 2007). Consequently, Burney (2008) describes the inductive approach as a bottom-up approach, which can be seen in Figure 4.3.

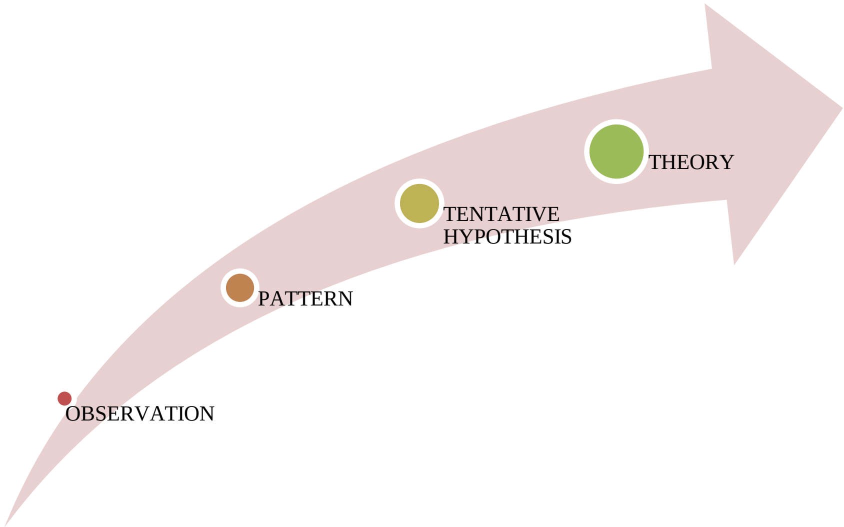


Figure 4.3: Inductive approach
Source: Burney (2008)

Consequently, Burney (2008) reported that this approach works from a precise observation to broader overview and theories. It also involves a degree of uncertainty and where the conclusion is like to be an idea. It is possible to work with the qualitative data and employ a diversity of methods to gather these data in order to institute diverse analysis of phenomena (Easterby-Smith et al, 2002).

This research is largely based on a deductive approach signifying the relationship between the theory and the research. Building construction projects risk is investigated and a risk management system for building construction projects in Nigeria will be developed. The risk management process will be observed to find out more about how risks involved in building construction projects are managed in Nigeria. In doing so, the observations may lead to new patterns and resulting in more details being added to the existing theory. Therefore, this thesis is based on a mixed-style method of reasoning, involving both deductive and inductive at some time in the project. It can be considered as a continuous cycle from theories down to observations and move up again to theories.

4.4 Research Strategy

The research strategy dictates the major direction of the research and constitutes one of the important decisions made by the researcher (Pathirage et al, 2008). Yin (2003) refers to research strategy also as research design and describes it as "*a logical plan for getting from 'here' to 'there', where 'here' may be defined as the initial set of questions to be answered, and 'there' is some set of conclusions (answers) about these questions*". Accordingly, Ghauri and Gronhaug (2005), selection of research design can be considered as the "bridge" between processes associated with the conceptual and empirical levels. Subsequently, researchers have proposed various types for the design of a research. The research design (which can be considered as the structure of the research) is to ensure that the acquired evidences will lead the researcher to achieving a clear answer to the questions of the research. Marshall and Rossman (1999) reports that a research strategy consists of the overall rationale, site selection, population selection (or both), the researcher's role, data collection methods, data management, data analysis strategy, trustworthiness features and a management plan. Trochim and Donnelly (2008) have classified research designs into three main types of randomized (true experiment), quasi-experiment and non-experiment. Other design types proposed by authors are case study, causal, observational, philosophical, descriptive, cross-sectional, action research, exploratory, historical, sequential, and longitudinal. Among all these different types, Hair et al, (2007) have grouped them into three. These are exploratory, descriptive and casual design. Selecting which type of design is appropriate for a research depends on factors such as nature of the research problem (question), the personal experiences of the researcher or sometimes even the type of audience the researcher is writing the research for.

The thesis identifies the risks factors associated with building construction projects in Nigeria and consequently, develops a risk management system that will improve building construction performance. Considering the design types proposed by Hair et al, (2007), the exploratory research design is appropriate. It is designed to discover new relationships, patterns, themes, ideas etc.

4.4.1 Research Methods

Data is collected from different sources using various methodologies. According to Blaxter et al (1996), the data required can be classified as qualitative if it comes in descriptive form, while they are regarded as quantitative if they come in numerical format. The proper selection of quantitative and qualitative methods depends on the understanding of their application to the research context which is vital to the success of the research in terms of presenting the phenomenon being studied. According to Saunders et al (2007), the chosen research method can be any method of these strategies depending on the type of research questions and what is required for answering them.

4.4.1.1 Quantitative Method

This is derived from experimental and statistical method in natural science (Layoux, 2005). A significant basis of methodological capability in quantitative research is the degree to which data are closely associated with theoretical opinion. Functioning definitions and methods are linked to prescribed construct definitions in this type of research (Feilden, 2008). Quantitative data refers to every numerical data or contained data that is quantified to help the researcher answer research questions and meet the objectives and can be a product of all research strategies such as experimentation, examination, case study, action research, stuck theories, ethnography and archival research (Saunders et al, 2007).

Creswell (2003) identifies some characteristics of quantitative research as follows: it views truthfulness or reality to exist in the world. This can be objectively and quantitatively measured in terms of the relationship between the investigator and what is being investigated. The quantitative research paradigm suggests that the researcher should remain distant and independent of what is being researched to ensure an objective assessment of the situation.

Easterby-Smith (1991) and Amaratunga, Baldry, Sarshar and Newton (2002) identifies some strengths of quantitative methodologies which include: allowing comparison and replication; reliability and validity may be determined more objectively than qualitative techniques; emphasizing the need to formulate hypotheses for subsequent verification; helping to search for causal explanations and fundamental laws; and, generally reducing the whole to the simplest possible elements in order to facilitate analysis. Creswell (2003) further states that in quantitative research, concepts, variables and hypotheses are selected prior to the study and remain fixed all through the study as the aim of the study is to develop generalizations that contribute to the theory and enable a researcher to better predict and explain some phenomena.

However, Myers (2009) argues that a major disadvantage of quantitative research is that, as a general rule, many of the social and cultural aspects of the organizations are lost or are treated in a superficial manner. According to Saunders et al. (2009), quantitative data convey very little meaning to most people before they are processed and analyzed. Quantitative analysis techniques, such as graphs, charts and statistics, allow researchers to explore, present, describe and examine relationships and trends within data. Quantitative data can range from simple counts such as the frequency of occurrences to more complex data such as test scores, prices or rental cost. In contrast to quantitative approaches, qualitative methods look at ways of increasing the richness of the data about the social process in a research problem and tend to be subjective (Bryman, 1995).

4.4.1.2 Qualitative Method

This method is primarily not on pre-determined hypothesis but on related understanding of complex realities and processes whereby, the questions and hypothesis appears successively as the investigation progresses (Layoux, 2005). Qualitative data is each and every one of the non-numeric data or data that cannot be quantified and can be a product of all research strategies such as experimentation, investigation, case study, action research, stuck theory, ethnography and archival research (Saunders et al, 2012). It assists in helping the researcher develop theory from their data. It is used to answer questions about the nature of phenomena with the purpose of describing and understanding those phenomena from the informant's point-of-view (Leedy, 1997). Consequently, Cornford and Smithson (1996), report that the qualitative research adopts the scientific model of a generalizable objective product from the research work. Therefore, it is probably wrong to make the distinction between quantitative and qualitative research simply on the use or absence of numbers. Sykes (1990) ascertained that the strength of qualitative research lies in the flexible and responsive interaction between interviewer and respondents. Yin (2009) noted that qualitative research helps to explain complex issues, within the natural settings of the research phenomenon, in detail. According to Strauss and Corbin (1990), qualitative research mostly means, "any kind of research that produces findings not arrived at, by means of statistical procedures or other means of quantification".

Qualitative research does not depend on the researcher knowing all the characteristics and categories of a subject ahead of time (Morse, 2003) but rather, allows concepts to be developed and refined as the research progresses. Myers (1997) and Oates (2006) further ascertain that qualitative research can be synonymous with positivist, interpretative or critical research paradigms. Zikmund (2003) states that there is no best research methodology but rather that the approach adopted depends on the research questions and research objectives that the research seeks to answer. In addition, the decision to adopt any research methodology is always a compromise between options and choices. Jenkins (1985) states that the key to selecting the best methodology consists of two factors:

I. Awareness of the research aim
II. Recognition of the available methodologies and understanding their relative strengths and weaknesses.

This research however, employs a mixture of both qualitative and quantitative research because all building construction risks are not numerically quantifiable and moreover, this process involves people and organizations, where the intangible issues such as mentality of the people or culture of the organization play a dominant role. Hence, a combination of both strategies is used here to cover statistics (quantifiable data) and people's knowledge and past experiences (abstract data).

4.4.2 Data Collection Method

This research, as in many other research areas, uses both primary and secondary sources of data. According to Cameron (1999), from the primary data, the researcher collects either by direct observation, measurement, interviews, questionnaires or other means which can be modified to his requirement to give answers to exactly the question which concern him, from a suitable sample while the secondary data is a process of reanalysing data that have previously been collected for some intention (Saunders et al, 2009). They are other people's facts and figures, which may be surveys, carried out by other people; sets of government information such as population census, company report, academic research journal report, etc. The utilization of secondary data saves time and money, and can be beneficial because part of the background needed for the research has been already surveyed with a pre-established degree of validity and reliability. The researcher can re-use them without the need for re-examining them. However, using the secondary data may not be quite adequate for the research questions because they have been collected for other studies with diverse objectives (Craig and Douglas, 2000) but it can provide a baseline for a research which is about to start and be useful in designing the appropriate methodology by identifying key issues and data collection methods.

A review of available literature can be considered as one of the sources for collecting the secondary data.

In this research, books, journal articles, online data sources and documents, and catalogues about construction projects, project management, risks associated with construction projects and risk management process were included. The selected case study for this research is the Nigerian construction sector and therefore, more information about the country, economy and building construction projects there had to be achieved. Therefore, reviewing and analysing these data was used to contextualize the case study and strengthen the arguments in research by providing both quantitative and qualitative evidence. This also helped the researcher to analyse the collected data from primary sources about the Nigeria construction environment more robust and in-depth. After collecting secondary data, in order to select the appropriate methods for collecting primary data, previous studies are reviewed in the following section.

4.4.2.1 Various Past Studies and their Data Collection Methods

Having reviewed past studies of various authors in developing countries, a summary has been given below, explaining the objectives of each research in addition to the data collection methods employed for them.

Smith and Bohn (1999) evaluated small to medium contractor contingency and assumption of risk. The aim was an investigation into the use of contingency in construction firms. They conducted interview with 12 contractors in order to collect their required information. (Qualitative)

Nasir, McCabe, and Hartono (2003) evaluated risk in construction-schedule model and developed a method to assist in the determination of the lower and upper activity values for schedule risk analysis. The study undertook usage of questionnaires and also case studies. (Mixed)

Wang and Chou (2003) examined risk allocation and risk handling of highway projects in Taiwan and recognized risk allocation by contract clauses and analyzed its influences on the contractor's risk handling strategies. Data were collected from different sources including case studies, documents, interviews and observations. (Qualitative)

Wang, Dulaimi and Aguria (2004) developed a risk management framework for construction projects in developing countries. Collecting data was done by posting 400 hardcopy questionnaires to selected companies, with only 31 valid responses being received. (Quantitative)

Tang, Qiang, Duffield, Young and Lu (2007) studied risk management process in the Chinese construction industry to investigate this process from the perspective of project participants. They distributed 115 questionnaires to different groups of people in different cities in China, and also conducted interviews with participants. Case study was also used as another method for considering the risk management practices in Three Gorges Project, which is one of the largest projects being undertaken in China. They made use of direct observation and evaluation of published project documents. (Mixed)

Sonmez, Ergin and Birgonul (2007) carried out a study on determination of cost contingency in international projects and focused more on determining the financial impacts of risks during the bidding phase. They used questionnaire as a means of collecting data and sent 48 questionnaires to international Turkish contractors. (Quantitative)

Liu, Li, Lin and Nguyen (2007) studied key issues and challenges of risk management and insurance in China's construction industry. For collecting the data, 150 questionnaires were sent to different groups of people via e-mail, mail and fax and 37 were selected out of the 41 responses being received. (Quantitative)

Hassanein and Afify (2007) investigated contractor's perceptions of construction risks and their attitudes towards risk identification and management. Data were collected from distributing questionnaires and also documents such as bid evaluation report and tender documents. (Mixed)

Perera, Dhanasinghe and Rameezdeen (2009) carried out a research about risk management in road construction in Sri Lanka. The aim was to find out more about risk responsibilities of contractual parties and improving risk-handling strategies. They adopted multiple case studies approach for validating the result through replication and therefore focused on two road projects. They also used multiple sources of evidence including semi-structured interviews, company documents, bill of quantities and archival records. (Qualitative)

Liu and Low (2009) undertook a study on developing an organizational learning-based model for risk management in Chinese construction firms and established a conceptual framework linking organizational learning with risk management. They distributed 38 questionnaires to mainland China and Singapore and also conducted case studies and 15 semi-structured interviews. (Mixed)

The aforementioned studies reviewed were all researching about construction risk in different countries, from various parties' perspectives and also the risk management processes applied for managing those risks. In finding out details about the projects and the country (environment) in which they were taking place, various data collection methods were used. Predominant methods employed were questionnaire and case study, which are appropriate for investigating knowledge, experience and opinion of people involved in construction projects.

4.4.2.2 Chosen Data Collection Methods

The selected research method for this study follows a mixed methods approach which involves four main stages as follows:

1. A review of literatures to establish the knowledge gap in construction risk management.
2. Development and use of questionnaire targeting the building construction sector in Nigeria to acquire data on critical risk factors affecting their business operations.
3. Apply modelling and simulation techniques to understand how risk factors affect performance. The Bayesian belief network is adapted to model risk assessment/management in building construction environments.
4. The exploration of two case studies involving interviews with project managers within construction organizations to validate the survey and Bayesian belief network model outcomes.

The survey strategy which formed the activity in (2) above was chosen because of the multi nature of the stakeholders in Nigeria, these being contractors, clients, consultants, project managers, engineers, and developers. Avison (1993) highlights that surveys are useful in obtaining consistent data from a large number of people and patterns are then searched for in the data. Surveys do not always use questionnaires but can use interviews, observation and documents. However, in this research, a questionnaire survey was believed to be the most appropriate method to learn about perceptions of the job in question, and stakeholders' behaviour (Rea and Parker, 1997), and to demonstrate any differences between target groups (Burns, 2000). In this study, differences in attitudes and experiences among contractors, subcontractors and their owners/clients were of most interest.

The research design describes the way in which data is collected and analysed in order to answer the research questions (Bryman and Bell, 2003).

4.4.2.2.1 Literature Review

A critical literature review was undertaken during the first phase of this research. Basically to compare the research idea with the existing knowledge, to check the viability of the proposed research (thus avoiding repetition), to learn how to develop an appropriate methodology, to suggest routes for advancing knowledge, and to help in refining the objectives and research questions (Fellows and Liu, 2003). The survey of the literature, specifically on construction risk management theory, helped the researcher to understand the requirements, benefits and problems associated with building construction project risks. This literature consisted of a careful review of textbooks, specialist journals, newspaper publications, and electronic sources, and the secondary data gathered through these means provided the ability to make useful comparisons with the primary data collected during the questionnaire survey.

In reviewing the literature, the researcher focused on risk management in the construction industry, this being precisely pertinent to the aim and objectives of the study.

4.4.2.2.2 Design and Administration of the Questionnaire

The questionnaire is a data collection technique where an individual is requested to respond to similar series of questions in a prearranged order (DeVaus, 2002 as cited in Saunders et al, 2012). The purpose is to enable the researcher recognise and explain the degree of disparity in answers on exact topics and to find for any relationships between views on one set of questions to position on another (Cameron, 1999). Questionnaire uses the descriptive research, in that the approach and views of the questionnaires in an organisational procedure will facilitate the researcher in recognizing and illustrating the inconsistency in different phenomena (Saunders et al, 2009). The types of questionnaires are described in Figure 4.4.

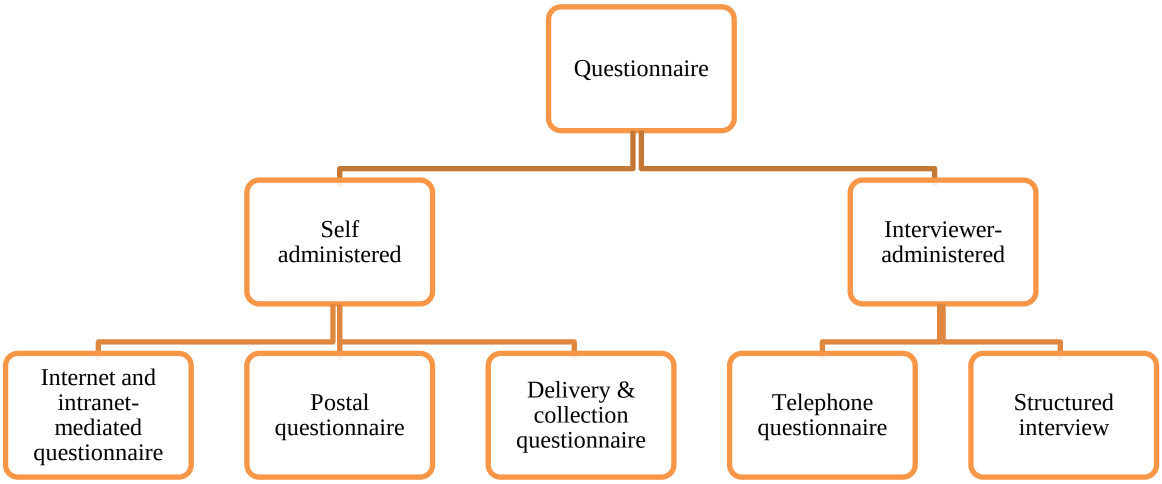


Figure 4.4: Types of Questionnaire
Source: Saunders et al (2009)

Knight and Ruddock (2009) reports that when developing a questionnaire there should be careful consideration in its design. This is to ensure that the data generated can be analysed in the way the researcher wishes, which is mostly done through statistical approach. Furthermore, the questions included must be constructed to ensure reliability and validity of the information obtained, and is designed in a very simple form (Peterson, 2000). This demands that they should be brief, relevant to the topic, clear and unambiguous, specific, and objective (Peterson, 2000). The entire exercise should be cost effective, meaning that only questions for which answers are definitely needed should be included. Once formulated, a draft questionnaire should be pre-tested since this procedure is vital to its success as a research instrument. Initially, the pilot should be with another knowledgeable and academic person (the supervisor of a research project), and with professionals and experts in the field. This exercise may be in two stages, the first one focusing purely on short questions rather than the whole instrument, and the second one to consider all the questions together in the particular sequence that they will appear in the questionnaire. This exercise is carried out to obtain feedback to inform the final instrument. Short questions can be asked verbally, face-to-face to gain immediate feedback, and then the final questionnaire can be constructed.

In this study, the questionnaire was designed carefully and then given to three experts in the governmental public sector, in the private sector, and a university professor for refinement. This procedure was in accordance with the best practice advocated in the literature, which requires that a questionnaire should be checked thoroughly before being employed so that the researcher is certain the instrument is easy to read and understand and is not likely to prevent any confusion to respondents (De Vaus, 2002; Baker, 2003). Hence, the questionnaire was developed in such a way that it was of a manageable length. This was done because most individuals in the working environment have no time to devote to research and it was essential not to cause impatience amongst the respondents.

Clearly in this research, time was considered to a very great extent. As discussed earlier, the research is done in Nigeria. Culture plays a dominant role in any environment in which the research is about to be done. In the Nigerian culture, talking about risk is talking about something dangerous which should be prevented. According to Avazkhah and Mohebbi (2010), project risk is an unpredictable event should it occur will have negative influences on the project objectives; causing delay, suspension or failure of the project.

Due to the existing culture in Nigeria and also what is defined in majority of the books and articles about risk in Nigeria, perception of risk in people's minds are more or less similar and in agreement with the definition presented above. They mostly believe that risk is a negative and bad event that may either happen or not (there is no chance of something positive to happen when talking about risk). Therefore, because of the predominant perception about risk in Iran, questionnaire is designed based on only the negative consequences of risk (a copy of the questionnaire is available in Appendix D). Considering both positive and negative consequences of risk in the questionnaire and interview would be problematic for this case study since the researcher might have to suggest the answers to participants while explaining positive consequences of risk to them. Hence, although the literature in previous chapter covered both positive and negative consequences of risk (see section 2.3.2), it is important to clarify that the word "risk" in this thesis is referred to the negative consequences of the unforeseen event which is usually called threat.

Hence, bearing this in mind, the questionnaire was constructed of multiple choice and closed questions. The questionnaire and a covering letter (see appendix D and E) was delivered to contractors, subcontractors and project owner (clients) of thirty eight (38) construction companies across Port Harcourt, Yenagoa and Owerri, explaining the purpose of the study, outlining the benefits of completing the questionnaire and reassuring the respondents of the confidentiality of their data. The questionnaire, consisting of three sections, was developed based on literature review. The first comprises background questions about the respondents and their organisational information. The second part deals with general issues about risk in construction projects for contractors and subcontractors. While the third part investigates risk factors within building construction projects, according to their experiences based on their likelihood of occurrence and impacts on projects. At the end of the questionnaire, space was provided for the respondent to add any comments they wanted to make.

One way of ensuring co-operation from potential respondents to a questionnaire is to promise feedback on the results of survey and the overall research outcome (Knight and Ruddock, 2009). The provision of feedback is made much easier nowadays by the use of information technology, since respondents who are interested in receiving such information can simply be asked to provide their email addresses at the end of the questionnaire, and this was indeed done in this study. However, no strategy guarantees a hundred percent response rate, and in assessing the minimum number of responses for statistical analysis to be possible, the researcher must also determine the likely number of questionnaires to distribute in order to allow for non-completion and spoilt questionnaires (Knight and Ruddock, 2009).

4.4.2.2.3 Simulation and Modelling

The application of modelling and simulation techniques in solving risk management concerns has been reported by Smith, Merna, and Jobling (2006). Modelling and simulation may be described as the process of investigating the behaviour of a system in a simulated environment. The process may involve describing a system mathematically while taken into consideration system variables and constraints. Modelling may be computer based or mathematically expressed. According to Smith et al (2006) mathematical modelling seeks to optimise or minimise the objective function while optimization task in risk management often seeks to identify the course of action by either maximising returns or minimizes expenditure. However, the alternative to mathematical representation of risk management decisions is the descriptive approach, which provides insight into the project considered (Smith et al, 2006). In this research, Bayesian belief network (Stamelos, Angelis, Dimou and Sakellaris, 2003) is adapted to model risk assessment/management in the Nigerian building construction environment.

4.4.2.2.4 Designing and Administration of Case Studies

The case study technique is valuable in that it enables a study to be set in a particular context, and for research to be undertaken in various phases (Knight and Ruddock, 2009), that often involve the collection of many different combinations of data, such as through interviews and documentary review (Fellows and Liu, 2003). This strategy allows the researcher to triangulate their evidence and thus be more confident in testing a particular concept or theory (Yin, 2003a). Commonly, the case study technique uses a certain amount of quantitative data to reinforce the qualitative primary data.

The researcher followed the advice offered by Yin (2003a) and Knight and Ruddock (2009) in respect of case study investigation, using this to validate the results of the questionnaire survey and Bayesian belief network model. In deciding to explore particular cases, the researcher gave consideration to several factors, which include,

I. The time available to carry out the investigation
II. The availability of documentary information
III. Access to persons involved for interviewing and focus group discussion purposes
IV. The aim of the investigation
V. The number of cases

In addition to the identification and selection of the cases involved, it is also important to determine the exact unit of analysis, and in this research, the unit was building construction project. In this regard, it was decided to adopt a multiple case approach in which two different cases in projects from different organizations were explored. On the matter of the number of cases to examine, Yin (2003a) argues that a multiple case approach (involving two or more cases) strengthens the validity and generalisability of results, providing the researcher with more confidence about the outcomes. Moreover, he reports that several cases can be chosen in order to demonstrate distinct characteristics or similarities/differences. Obviously, where the cases confirm similarities, the results will always be more compelling, and, therefore, easier to defend.

All the information collected in this study was of interest to the researcher, despite it varying in both relevance and reliability. As reported by Knight and Ruddock (2009), a case study affords the opportunity to incorporate different kinds of evidence, which

Gillham (2000) and Yin (2003a) have generally grouped into documents, archival records, interviews, direct observations, participant observation and physical artefacts.

Yin (2003a) also argues strongly that case studies should indeed be designed so as to encompass a variety of methods of data collection and to expect all of these to figure in the final report about the case. In this respect, Yin (2003a) indicates that “the larger study’s overall report would then be based on the pattern of evidence from both case study and the other methods”. He also confirms that “the questions for the case study might only have emerged after the survey and the selection of the cases might have come from the pool of those surveyed or contained within the archival records”. In this scenario, the case study questions as Yin (2003a) argues are likely to be closely co-ordinated with those of the other methods.

Three main sources of data have been used in this study to capture the overall circumstances of the case projects, these are: Interviews with construction professionals, documentary evidence and direct observations.

1. Face to face and telephone interview with construction stakeholders: Putins and Petelin (1996) argue that interviews are an extremely important form of communication in society. They are a means by which information is exchanged between individuals and successful communication is achieved. Although interviews are essentially an exchange of information, nonetheless Dwyer (1993) distinguishes interviews from casual conversations on the basis that interviews are planned, prearranged, structured, controlled by the interviewer, have a predetermined purpose and take place between two or more people of different status. Marshall and Rossman (1999) suggest that when a research has a descriptive and exploratory focus, as it has in this research, the appropriate research strategies should be field studies comprising in-depth interviews. In this research, the interviews assisted in gaining in-depth understanding of some of the issues outlined in the self-administered questionnaire. Walsham (1995) and Levy and Powell (2003) acknowledge that interviews are a key feature of successful cases as they provide the best access to interpretations and views of participants regarding actions and events which have taken place.
2. Documentary evidence: The researcher made use of the documents of the companies that were interviewed. Documentation was used to form the basis for understanding the background of the case study organization, the roles of the

project managers and the workflows within the company. Furthermore, information on some of the documents was used to confirm, and as an add-on to, the evidence gathered from other sources. The review of the organization's documents enabled the researcher to probe further in order to confirm some details, thereby avoiding contradictions. Inferences were also gathered from documents which at a later stage served as suggestions for further investigation. Documents referred to during the researcher's stay in the companies typically included memoranda, agendas, minutes of meetings, construction progress reports, administrative documents etc. This assisted in providing further evidence to other data collected via interviews and surveys, although Yin (1994) states that researchers must not regard documents and records as a pure account of facts that have happened. However, Myer (2001) states that the use of documents is important because they can be used as inputs to the interview guide and used to identify statements made by key people in an organisation. The use of documents can also be helpful in counteracting biases of interviews. Analysis of the documents assisted in understanding the reactions and feelings captured in the survey and interviews, ensuring results were placed in the right context (Grainger and Tolhurst, 2005). Moreover Bryman (1989) notes that analyses of documents and records help to examine the validity of information obtained by other methods and can also provide further information on issues that the researcher is interested in gathering. The documents were analysed bearing in mind the aim of the research. This was done by carefully reading the documents in order to understand the general focus of each of them. Afterwards, the researcher focused on key information that was relevant to the present research and then incorporated that information in the report since the major reason for reviewing the documents was to back up facts already obtained from the interviews.

3. Direct observations: Observation is a methodology consisting of watching what people do, listening to what they say and sometimes asking them to clarify certain issues. Stake (1995) and Gillham (2000) identify the benefits of engaging in observation which include looking at what people actually do, rather than what they say they are doing, or why and how they should be doing it. Data were captured by carefully observing the construction activities of these companies and keeping field notes bearing in mind the aim of the research. The field notes were then written up and further compared with the information

provided by the participants during the interviews. Direct observation gave the researcher some added advantage in terms of observing the manner in which contractors especially, deal with clients, suppliers and sub-contractors. Adler and Adler (1994) argue that the major strength of direct observation is the fact that it is unobtrusive and does not require direct interaction with participants. Observation produces rigour when it is combined with other methods (Myers, 2001) and can illuminate the discrepancies between what people say in the interviews, casual conversations and what they actually do (Pettigrew 1990). It also helps to observe things that may routinely escape conscious awareness among participants (Kunda, 1992). According to Waddington (1994), the value of observational data is of substantial importance since it can assist the researcher to learn some aspects of organisational cultures in the various firms. The direct observations were made by the researcher to establish exactly how individuals behaved in respect of their projects rather than relying on their accounts of how they behaved.

As reported by Yin (2003), such an approach allows for triangulation of data as there are several sources of evidence. The objective of this entire approach was to elicit views from the stakeholders in the risk management process.

The applicability of a risk management model was tested through two ongoing case study projects with the interviewees. The building construction companies were all operating within Nigeria and mainly in Port Harcourt. The selection criterion was their willingness to participate in the study.

4.4.2.3 Sampling

Sampling is the means whereby the researcher is able to decrease the total data needed to be collected by taking into consideration only data from a subgroup instead of all likely cases or element (Saunders et al, 2009). This can be illustrated in Figure 4.5.

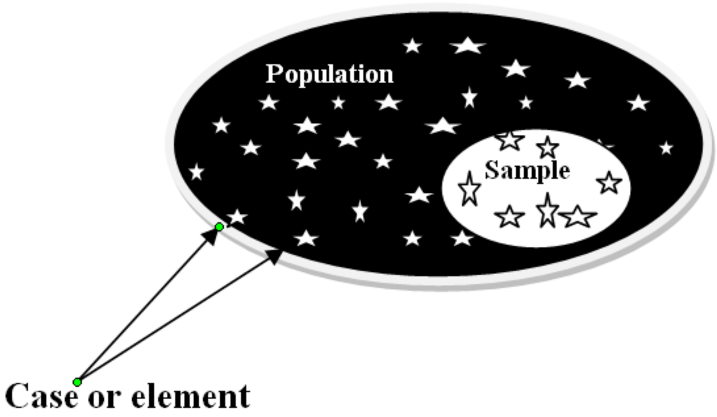


Figure 4.5: Population, Samples and Individual cases
Source: Saunders et al (2009)

According to Saunders et al (2009), the techniques for sampling are available in two types

1. Probability (random) or representative sampling- This is the process where the case that is collected from the population is recognised and is more often than not equivalent for all cases i.e. it is probable to answer the research query and to attain the purpose that need the researcher to evaluate statistically the description of the population from the sample (Saunders et al, 2009). This kind of technique is associated with survey and experimental research strategy. The process of representative sampling is divided into 4 stages;
   i. Identifying an appropriate sampling structure based on the research question or objectives.
   ii. Make a decision on a suitable sample size.
   iii. Select mainly appropriate sampling technique and decide the sample.
   iv. Ensure that the sample is representative of the population.

Consequently, Saunders et al (2009) states five types of probability sampling, which are simple random, systematic, multi-stage, stratified random and cluster sampling.

2. Non probability (selected) or judgemental sampling- this is a method where every case being selected from the whole population is not recognised and it is not possible to answer research questions or tackle the purpose that need the researcher to produce statistical conclusion concerning the characterises of the population. This technique is essential because it gives a variety of options to select samples based on subjective decision. The common types of non-probability sampling are convenience samples, purposive sampling, snowball sampling, and quota samples.

Moser and Kalton (1971) mentioned that bias in the selection of the sample can be introduced if; the sampling is not random; and the sampling frame that serves as the basis for selection does not cover the population adequately, completely or accurately; and some sections of population are impossible to find or refuse to co-operate.

Therefore, the sample selection procedure adopted in this study is the non-probability sampling. The target sample in this study is composed of contractors, subcontractors and clients. This was deemed the most appropriate target for any research seeking to apply scientific management techniques in construction project management. The following factors served as the basis for selecting the sample: size; experience; share of the industry's business; expertise; and specialisation.

For logistic and cost reasons, the sampling was restricted to construction practitioners located in Rivers State, Bayelsa State and Imo State of Nigeria. Covering the whole country would be is costly and lengthy due to inefficient postal services. Moreover, it was assumed that the vast majority of construction organisations are in this Niger Delta region due to the vast ongoing construction carried out. On balance, it is believed that although the survey did not cover the whole country the level of distortion of the sample was kept to a minimum.

A total of 650 questionnaires and covering letters were delivered between August, 2014 and September, 2014 to contractors/subcontractors and project owner (clients) of thirty eight (38) construction companies across Port Harcourt, Yenagoa and Owerri, explaining the purpose of the study, outlining the benefits of completing the questionnaire and reassuring the respondents of the confidentiality of their data. In total, 343 questionnaires were returned in the analysis representing 53% response rate. Three hundred and five (305) were returned by contractors and subcontractors while thirty eight (38) were returned from clients. This is also similar to a survey conducted by Agyakwa-Baah and Chileshe (2010) among a similar frame and drew a response rate of 57%. Thus, the response rate was deemed adequate for the purpose of data analysis. Akintonye and Fitzgerald (2000) argue that this is way above the norm of 20-30 percent response rate in most postal questionnaire of the construction industry.

4.5 Data Analysis

At this stage, the researcher must demonstrate capability in the art of data analysis, be aware of how to present the data, and how to explain it without introducing any bias or distortion. At the same time, the researcher should present it in such a way so that it induces the reader to think about what is being provided. Presenting many numbers that have very little relationship to each other and producing large data sets should be avoided, unless they encourage the reader to compare different pieces of data and reveal other findings. Panas and Pantouvakis (2010) note the need to continually evaluate and re-evaluate results and to be sensitive in data analysis in order to gain an in-depth perspective of a study's implications. In addition, having a good understanding of statistical analysis is a requirement for many researchers who choose to analyse their data using statistical techniques. Most researchers deal with inferential statistics, which indicate whether the alternative hypothesis is likely to be true, thereby helping to confirm or reject predictions (Field, 2009) as well as whether the model fits the obtained data. If a model fits the data well, then it can be assumed that the initial prediction is true, so as to gain confidence in the alternative hypothesis. Statistical Package for Social Science (SPSS) is the most used statistical analysis software and is extremely powerful, being able to perform the full range of statistical procedures with chart drawing facilities. Additionally, it is straightforward to set up data entry and to analyse the results (Knight and Ruddock, 2009).

4.5.1 Types of Data

According to Maylor and Blackmon (2005), there are four types of quantitative data, and understanding the differences between these is important, because it affects what they mean and what can be done with them.

1. Nominal data: Any number assigned to a nominal variable is arbitrary, rather than essential of that variable. Many qualitative variables are converted to nominal values in scientific research. For example, the record of sex of a respondent as a 1 if it is a man and 2 if a woman. The choice of 1 and 2 is arbitrary.
2. Ordinal data: Items on an ordinal scale are set into some kind of order by their position on the scale. This may indicate such as temporal position, superiority, etc. for example, assigning numbers to respondent's level in the organization: 1= plant manager, 2 = supervisor, 3 = direct labour. This does not imply that a

direct employee has three times as much as levelness as a plant manager, or that a supervisor has exactly half the levelness of the two, but they can rank them in some consistent order. Ordinal measures are often associated with attitude measures, such as the familiar ranked-order responses known as a Likert-type scale.

3. Interval data: Interval data (also sometimes called integer) is measured along a scale in which each position is equidistant from one another. This allows for the distance between two pairs to be equivalent in some way. This is often used in psychological experiments that measure attributes along an arbitrary scale between two extremes. Examples of interval measures include the year and the temperature in degree Fahrenheit (or Centigrade).
4. Ratio data: In a ratio scale, numbers can be compared as multiples of one another. Hence, one person can be twice as tall as another person. Consequently, the number zero has meaning. Hence, the difference between a person of 35 and a person 38 is the same as the difference between people who are 12 and 15. A person can also have an age of zero. Ratio data can be multiplied and divided because not only is the difference between 1 and 2 the same as between 3 and 4, but also that 4 is twice as much as 2. Interval and ratio data measure quantities and hence are quantitative. This is because they can be measured on a scale; they are also called scale data.

4.5.2 Data Analysis Method

In this research, once the data were collected, they had to be analysed and preferably illustrated in tables.

After collecting the questionnaires from participants, a code book was prepared comprising distinctive codes for different sections of it. Data written and marked in each questionnaire was entered into Microsoft Office Excel according to the code book and using the unique ID which was provided for them before distributing to respondents. The code book contains a code for each section which was then sub-coded for the parts included in that section, and details of each section were shown in a separate sheet in the Excel file. Therefore, quantitative data were analysed using Microsoft Office Excel and Statistical Package for Social Science (SPSS Release 23.0.0) computer programme to analyse the ordinal data generated. The analysis of the data consists of descriptive statistics to depict the frequency distribution and central tendency of responses to fixed response questions. A 5-point Likert scale on a five-point Likert rating scale was used in this research to quantify risk likelihood as improbable (1), rarely (2), occasionally (3), probable (4) and frequent (5) and also, risk impact as marginal (1), little (2), moderate (3), great (4) and extreme (5). Analysis of data obtained would involve parametric test involving means and standard deviation, as the distribution of parametric for the data. Parametric tests in research such as t-test and Analysis of Variance (ANOVA) would be employed to compare variables as well as correlation and regression to study relationships between variables (Saunders et al, 2012).

The level of criticality of the risks in construction projects based on the likelihood of occurrence and their impact on the project and opinion of participants about various aspects of construction projects were evaluated. The results from the questionnaires demonstrated how different categories of people perceive risk while managing building construction projects. Results are illustrated and discussed completely in Chapters 5 (Questionnaire analysis).

4.5.3 Model Development

Result obtained from the questionnaire analysis in this research is used to present a risk assessment methodology based on the Bayesian belief network (BBN) model, which is an effective tool for knowledge representation and reasoning under conditions of uncertainty, structural learning procedure, combination of different source of knowledge, explicit treatment of uncertainty and support for decision analysis and fast responses for risk assessment. The Bayesian belief networks are Directed Acyclic Graphs (DAGs) expressing probabilistic cause–effect relations among the linked nodes (Stamelos et al, 2003). Each node represents a random variable that can take discrete or continuous values according to a probability distribution, which can be different for each node (Stamelos et al, 2003). The relationship among the variables association starts from influencing variable (parent node) and terminates in influenced variable (child node) (Stamelos et al, 2003). Consequently, intermediate parameter (child node) is a member of the set of the relating variables. The absence of an arc connecting two nodes is an indication of conditional independence between the corresponding variables. This may indicate that there are no situations in which the probabilities of one of the variables depend directly upon the values of the other. Consequently, the Bayesian belief network will be constructed by structural learning and parameter learning using the Netica 5.0 application software. More on the Bayesian belief model has been discussed and applied extensively in the subsequent chapter.

4.6 Reliability and Validity

It is important to evaluate the quality of data interpretation by examining the reliability and validity of the research findings. Whatever research methodology is adopted for a research, reliability and validity issues have to be considered as they are tests of the trustworthiness of the measurement instruments used in research (Golafshani, 2003). Validity and reliability are also regarded as concepts central to the credibility of a research (Miles and Huberman, 1994), while, according to Saunders et al. (2009), they reduce the possibility of obtaining a wrong answer.

Validity is concerned with whether the measure used is actually measuring the concepts is supposed to be measuring (Hardy and Bryman, 2004).Validation involves taking the research findings back to the participants and determining whether or not those findings conform to the experiences of the participants (Silverman, 2001). Consequently, reliability refers to consistency where the characteristics include that of the instrument and the conditions under which it is administered (Cooper and Schindler, 2001). Reliability focuses on whether the process of the study is consistent and reasonably stable over time and across researchers and methods (Miles and Huberman, 1994).

This research applies the triangulation method to increasing the reliability and validity of the results and greater confidence in findings. Triangulation was originally conceptualized by Webb et al. (1966). It involves employing more than one method or source of data while studying social phenomena. Using two different methods, questionnaires and case study, in addition to analysing secondary data strengthen the research findings.

4.7 Ethical Considerations

In the context of research, ethics refers to the suitability of the behaviour of the researcher in relation to the rights of those who become the subject of the work or are influenced by it. Cooper and Schindler (2008) define ethics as the “norms or standards of behaviour that guide moral choices about researcher’s behaviour and relationships with others”.

Ethical principles were applied in this thesis in order to prevent ethical issues, because people were involved in questionnaires and interviews and the researcher's behaviour with them was important. Participants were assured that their information is kept confidential, they have the right to withdraw at any time and everything is with their consent, there is no deception and they were informed about every single step. Ethics application was approved by the University of Wolverhampton ethics committee before the actual data collection started (see appendix F).

4.8 Overview of the Entire Research Process

From the foregoing discussion the diagram below (i.e. Figure 4.6) presents the entire research process for this study showing the various steps involved in carrying out the research.

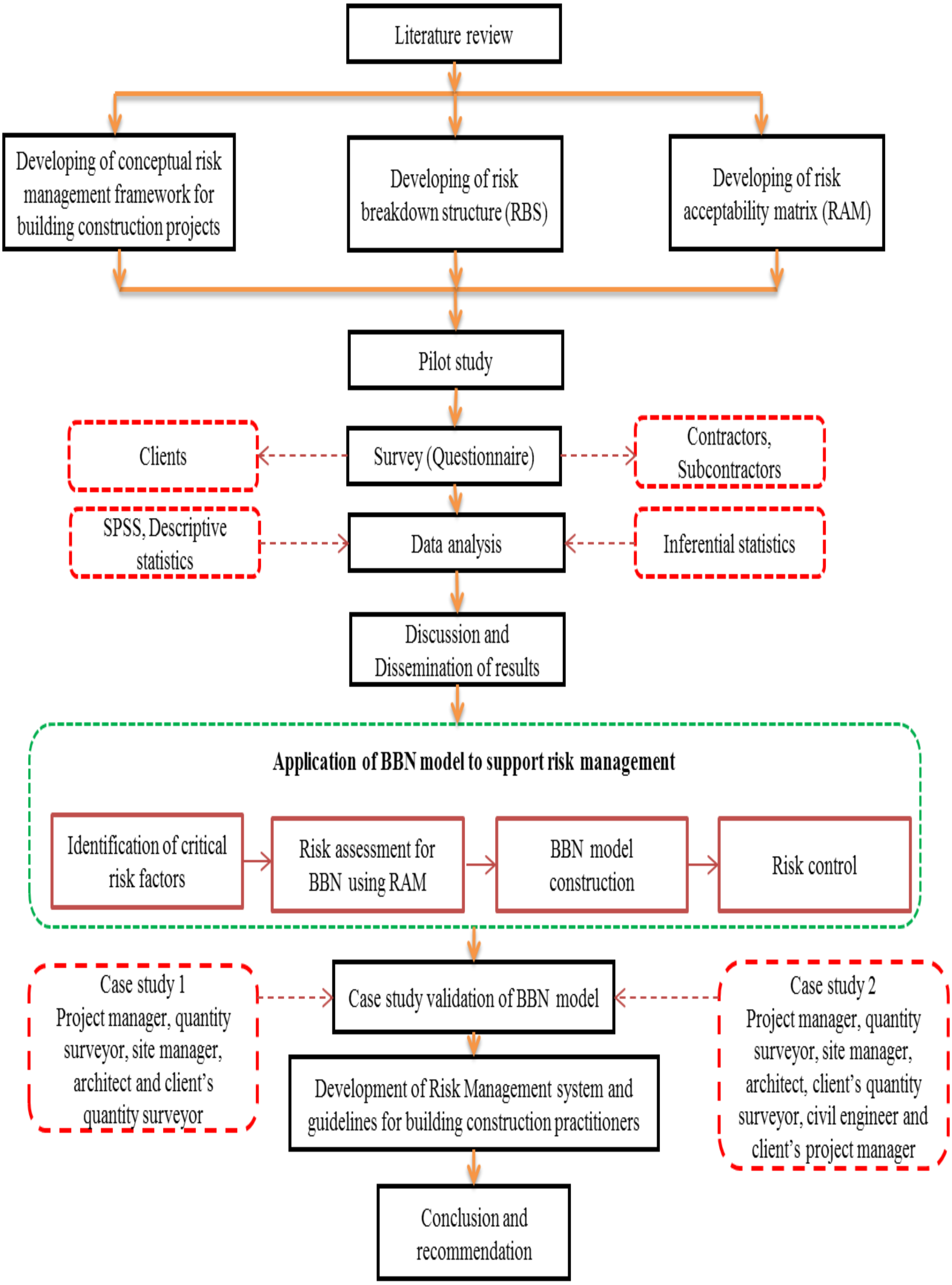


Figure 4.6: Research Process

4.9 Chapter Summary

In this chapter, the research methodology undertaken for answering the questions of the thesis was discussed comprising the rationale for the research approach adopted. The researcher adopts a mixed approach involving a combination of both qualitative and quantitative methods for this research. The researcher believes that a pool of information/data from multi-sources is more reliable. Consequently, the research tasks are carried out through four main stages. The first stage involves the use of literature review to establish the knowledge gap in construction risk management. The second stage involves the use of questionnaires targeting the building construction sector in Nigeria to acquire data on critical risk factors affecting their business operations. Thirdly, modelling and simulation techniques are used to understand how risk factors affect building construction performance. The Bayesian belief network is adapted to model risk assessment/management in building construction environments and finally, two case studies involving interviews, documentary evidence and project site observation with project stakeholders within construction organizations to validate the questionnaire survey and Bayesian belief network model outcomes. It was then continued with discussion on data analysis and finished with providing explanation about ethical considerations.

The next Chapter, Data Presentation and Analysis, discusses the quantitative (questionnaire) analysis of the collected data in-depth. The tables and diagrams illustrating the results of data analysis are also shown in next Chapter.

CHAPTER FIVE: DATA PRESENTATION AND ANALYSIS

5.0 Chapter Introduction

The previous chapter, research methodology, discussed the research methodology undertaken for this research including research approach, research design, Nigeria as the chosen case country, research strategies, data collection methods and data analysis methods adopted. This research seeks also to identify the major risk factors that have significant effect on building construction project performance in developing countries which is the second objective of this research. To address this objective, survey questionnaires were used to collect data from building construction organisations in Nigeria on their views about construction risk management in their projects. This chapter presents the responses to the survey, analyses of the survey data and discussion of the research findings.

5.1 Data Analysis

The data was analysed using descriptive statistics and inferential statistics. The descriptive statistical analysis carried out includes frequency distribution and measures of central tendency like mean and standard deviation while the inferential statistics include Analysis of Variance (ANOVA) and regression analysis.

5.2 Survey Response

Out of the 650 questionnaires distributed to construction organisations, a total of 343 questionnaires were returned which represented 53% response rate. The response rate was deemed adequate for the purpose of data analysis. Akintonye and Fitzgerald (2000) argue that this is way above the norm of 20-30 percent response rate in most postal questionnaire of the construction industry. The questionnaire was completed by three different participants made up of clients, contractors and sub-contractors which are involved in building construction projects. The definitions of the respondents have been described by the Nigerian Bureau of Public Procurement (2011) as;

Contractor: The natural person, private or government enterprise, or a combination of the above, who tenders to carry out the work that have been accepted by the employer and is named as such in the SCC (Special Condition of Contract) and the Contract Agreement, and includes the legal successors or permitted assigns of the contractor.

Sub-Contractor: Is the natural person, private or government entity, or a combination of the above, including its legal successors or permitted assigns, who has a contract with the contractor to carry out a part of the work in the contract, which includes work on the site.

The Client: Is the party named in the SCC (Special Condition of Contract) who employs the contractor to carry out the work.

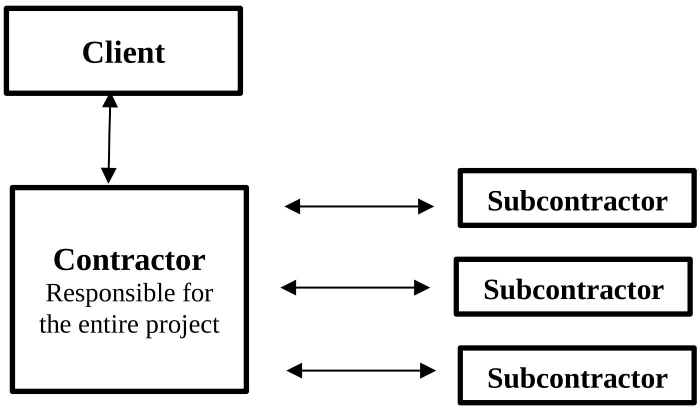


Figure 5.1: Relationship pattern in a building construction project

Figure 5.1 shows a simple relationship pattern of the aforementioned participants in a building construction project. More details will be provided for each of these groups regarding their responsibilities.

5.3 Presentation and Analysis of the Questionnaire Survey

A unique identity was written by the researcher on each questionnaire (before distributing) to keep record of the names of participants and also to structure the analysis. Questionnaires were made anonymous for confidentiality but details were only known to the researcher. Number of respondents (N) = 343.

5.3.1 Descriptive Analysis of General Respondents' Background Information

5.3.1.1 Professional Roles

Table 5.1 shows the distribution of respondents based on their profession. From Table 5.1, it can be seen that the respondents were professionals, who theoretically were capable of providing answers that reflected their knowledge and overall professionalism. The table shows that the majority of the sample were project managers (35.6%), and was followed by Architect (25.4%), Civil engineer accounted for 24.5% and the least were Quantity surveyor which accounted for 14.6%. This indicates that project managers were deeply involved in the survey and their views reasonably obtained.

Table 5.1: Distribution of the respondents based on profession

Profession	Frequency	Percent	Remark
Civil Engineer	84	24.5	
Architect	87	25.4	
Quantity Surveyor	50	14.6	
Project Manager	122	35.6	Dominant

*Dominant (more frequent)

5.3.1.2 Respondents' Years of Experience

In this section respondents were analysed according to their practical experience in building construction projects (Table 5.2). According to Table 5.2, 41.1% of the respondents had working experience between 6-10 years. This was followed by the category of 1-5 years with 22.7%. The respondents who had an experience between 21-25 years represented 3.5% of the respondents whereas the participants who had over 25 years of experience represented 0.3% of the respondents. In a country like Nigeria, it can be seen that people who work in the building construction industry especially in the private contracting companies have between 6-10 years working experience. This indicate that the respondents have sufficient experience as the respondents had up to 10 years of experience and, hence, have the ability to understand and discuss the main issues related to risk management in the building construction sector.

Table 5.2: Distribution of the respondents based on work experience

Work experience	Frequency	Percent	Remark
1 to 5 years	78	22.7	
6 to 10 years	141	41.1	Dominant
11 to 15 years	64	18.7	
16 to 20 years	14	4.1	
21 to 25 years	12	3.5	
Over 25 years	1	0.3	
None (no response)	33	9.6	

*Dominant (more frequent)

5.3.1.3 Project Management /Risk Management Experience

In this section respondents were analysed according to their practical knowledge of project management and/or risk management in building construction projects (Table 5.3). Table 5.3 shows that 47.2% of the respondents had risk management or/and project management experience while 52.8% think theymay have risk management experience. This indicates that a large amount of the respondents do not have sufficient knowledge of assessing and managing risks in their projects. This represents the existing culture in Nigeria about the concept of risk in projects and the lack of knowledge about the formal risk management processes. Construction practitioners in Nigeria should endeavour to be aware of project management/risk management process which will help them to reduce not only the likelihood of a risk event occurring in their project, but also the magnitude of its impact.

Table 5.3: Risk management or/and project management experience

Risk management or/and project management experience	**Frequency**	**Percent**	**Remark**
Yes	162	47.2	
Maybe	181	52.8	Dominant

*Dominant (more frequent)

5.3.1.4 Risk Encountered in Building Construction Projects

Table 5.4 shows the responses of respondents who encountered risk in their projects. As shown in Table 5.4, 98.3% of the respondents encountered risks in their projects while 1.7% demonstrated they did not encounter risk. From the preliminary statistics obtained in this investigation, it shows clearly to a large extent that the Nigerian building construction industry suffer from risk continuously which leads to cost and time overruns as well as quality problems as reported by majority of the respondents. Proper risk management implies control of possible future events and is proactive rather than reactive.

Table 5.4: Responses on those who encountered risk on their projects

Reponses	**Frequency**	**Percent**	**Remark**
Yes	337	98.3	Dominant
No	6	1.7	

*Dominant (more frequent)

5.3.1.5 Project Types

Table 5.5 summarises the distribution of project types. According to Table 5.5, most of the contruction projects were residential bungalow buildings (10.8%), this was followed by three storey building of two bedroom flats (9.3%) while the construction of model primary schools accounted for 0.3%. This result indicates that there are more construction practitioners into the construction of residential buildings in Nigeria.

Table 5.5: Distribution according to project type

SN	Name of the contruction project	Frequency	Percent	Remark
1	Administrative office blocks	11	3.2	
2	Bungalow residential buildings	37	10.8	Dominant
3	Church building	20	5.8	
4	Classroom block of holy Child Intl. Primary school Uga	11	3.2	
5	Construction of model primary school	1	0.3	
6	Construction of hospital buildings	4	1.2	
7	Double flat bungalow building	10	2.9	
8	6 bedroom duplex building	17	5.0	
9	Five bedroom bungalow flat	11	3.2	
10	Industrial building complex	10	2.9	
11	Camp buildings for Umuocham Emekuku community	10	2.9	
12	Parking structures and storage building	6	1.7	
13	Four storey commercial building	10	2.9	
14	Modern light intl. School Eket	11	3.2	
15	Departmental store building	8	2.3	
16	Dormitory for secondary school	6	1.7	
17	Concert hall building	6	1.7	
18	Construction of power station/plant building	6	1.7	
19	School auditorium	11	3.2	
20	Six bedroom residential duplex	7	2.0	
21	Chapel auditorium	9	2.6	
22	Nursing home building	9	2.6	
23	Three storey building of two bedroom flat	32	9.3	
24	Town hall	9	2.6	
24	Two bedroom bungalow	12	3.5	
25	City hall building	11	3.2	
26	Community hall	8	2.3	
27	Two bedroom apartments	11	3.2	
28	Factory building	18	5.2	
29	Two storey commercial building	2	0.6	
30	Taxi station building project Rumuokoro	9	2.6	

*Dominant (more frequent)

5.3.1.5 Role on the Project

Table 5.6 shows the respondents according to their roles in building construction projects. According to Table 5.6, contractors represented 44.3% and sub-contractors represented 26.8%. Other respondents which had other project roles such as consultants, architects, engineer etc. represented 17.8% while the least were clients, representing about 11.1%. This indicated that a large amount of the respondent in the survey have the ability to understand and discuss the main issues related to risk management in the building construction sector.

Table 5.6: Distribution of the role of the participants in their projects

Role	Frequency	Percent	Remark
Contractor	152	44.3	Dominant
Sub-contractor	92	26.8	
Others	61	17.8	
Clients	38	11.1	

5.3.2 Contractors/Sub-contractor Information and Performance in Projects

This section of the questionnaire consists of twelve questions related to building construction performance. The perception of construction practitioners is given in this section. Number of respondents (N) = 343.

5.3.2.1 Number of years their organisation has been working in the Nigerian construction industry

Table 5.7 summarises the distribution of respondents according to their years of experience in the construction business. Table 5.7 shows that most of the firms have been in business for about 6 to 10 years (62.4%), followed by those with experience of 1 to 5 years (22.4%) and the least was the category with over 20 years, representing 3.8%. This indicates that most of the organisations involved in this survey have sufficient experience within the Nigerian context. Hence, they can properly assess the likelihoods of risk occurring and the magnitude of risk in a building construction project.

Table 5.7: Distribution of years of experience in construction business

Years	Frequency	Percent	Remark
1 to 5 years	77	22.4	
6 to 10 years	214	62.4	Dominant
11 to 20 years	39	11.4	
Over 20 years	13	3.8	

*Dominant (more frequent)

5.3.2.2 The number of projects (in general) that have been awarded to the organisation during the last three years.

Table 5.8 summarises the distribution of respondents according to the number of project that they have been awarded over the last three years. Table 5.8 shows that about 44.6% of the respondents indicated that their firm had 6 to 25 projects awarded over the last three years, this was followed by those who had 51 to 100 projects awarded (21.0%) and the least were those who did not respond to this item. This indicates that a large amount of construction practitioners in Nigeria have carried out a number of projects in the last three years and are in the position to determine what challenges they encounter in their projects.

Table 5.8: Distribution of the number of projects awarded over the last three (3) years

Projects	Frequency	Percent	Remark
None(no responses)	36	10.5	
1 to 5 projects	42	12.2	
6 to 25 projects	153	44.6	Dominant
26 to 50 projects	40	11.7	
51 to 100 projects	72	21.0	

*Dominant (more frequent)

5.3.2.3 Factors causing poor performance in building construction projects

Table 5.9 shows the responses of respondents based of the poor performances of their projects. According to Table 5.9, 67.9% of the participants did not respond to this item. About 8.2% of the participants indicated that insufficient fund was responsible for poor project performance. This was followed by the 7.6% of those who opined that it was delay in payment and the least was one person (0.3%) who indicated that it was client not releasing enough money that was responsible for the poor performance of their projects. From the response in this section, it could be seen that most of the construction practitioners in Nigeria do not give proper and timely attention to identifying and managing risk. This effect as a whole is one of the major aspects causing building construction projects to fail and this findings agree with the studies of other researchers in developing countries (Yazdanifard and Ratsiepe, 2011; Oyewobi et al, 2011; Olowakiyesi, 2011; Dantata, 2008). Consequently, ignoring the chances of risks in a building construction project can bring about a lot of costs to the project sponsor hence, spoiling the relationship between an organisation and the client to which the project is being developed for.

Table 5.9: Responses on the poor performance of projects

Reasons	**Frequency**	**Percent**	**Remark**
None(no response)	233	67.9	**Dominant**
Client not releasing enough money	1	0.3	
Delay in payment	26	7.6	
Delay in payment of a satisfied stage of work carrier	5	1.5	
Inadequate preparation of bill of quantity	19	5.5	
Insufficient fund	28	8.2	
Insufficient materials	8	2.3	
Lack of fund	15	4.4	
Unavailability of materials	8	2.3	
Total	343	100.0	

*Dominant (more frequent)

5.3.2.4 Risk management implementation in building construction phase

Risk management implementation would help the project team to better prepare for potential risk affecting building construction projects. Table 5.10 shows the results of the implementation of risk management in project phases, Table 5.10 shows that 56.9% of the respondents addressed risk management in the project inception stage, 51.0% participated in the design stage, and 64.4% were involved in the project completion stage while majority (82.8%) of the respondents participated in the construction stage of the project. The results indicated that only a percentage of respondents (56.90%) prepare for risk management in the inception phases of their projects. Building projects encounter diverse risk in their life cycle. The greatest degree of uncertainty is usually encountered at the early phase in the project life cycle (Perry and Hayes, 1985). If major risks are not addressed early in the life cycle, they would magnify their effects in the later project phases (Pennock and Haimes, 2002). Thus, more attention should be drawn to the risk management early in the life cycle of newly built projects

Table 5.10: Responses on the phases of the project they participated

Phases of the project	Yes	%	No	%	Remark
Project inception	195	56.90	148	43.10	
Design	175	51.00	168	49.00	
Construction	284	82.80	59	17.20	
Project completion	221	64.40	122	35.60	

5.3.2.5 Risk Assessment Techniques Applied in Building Construction Projects

Table 5.11 shows the distribution of risk management techniques used in building construction projects by respondents. From Table 5.11, it shows that 13.7% of the respondents apply the technical approach of risk management technique, this was followed by expert judgment technique and the least was technical approach and assessment (0.6%). The key success indicators of construction management system(s) include completing the project with cost and time, within the planned budget and duration, and within the required quality, safety, and environmental limits (El-Karim, Naway and Abdel-Alim, 2015). However, from the results obtained in Table 5.11, it can be seen there are no established risk management systems that will help assist construction practitioners to manage risk affecting building construction projects in Nigeria. Inexperienced assessment of risks can have dire consequences for companies and the industry as a whole. Therefore, it has become necessary establish a risk management system that will improve the performance of building construction projects in without cost and time overruns while achieving optimal quality.

Table 5.11: Distribution of risk management techniques

SN	Techniques	Frequency	Percent	Remark
1	None (no response)	38	11.1	
2	Application of professional technique to the cost	11	3.2	
3	Assumption analysis	8	2.3	
4	Brainstorming and expert judgment	8	2.3	
5	Cost risk analysis	8	2.3	
6	Evaluate our LTI records	5	1.5	
7	Expert judgment	46	13.4	

8	Identification assessment, and technical response	5	1.5	
9	Impact assessment	6	1.7	
10	Modeling and construction	7	2.0	
11	Modeling and stimulation	9	2.6	
12	Risk analysis	27	7.9	
13	Risk analysis techniques	9	2.6	
14	Risk assessment	9	2.6	
15	Risk probability	10	2.9	
16	Risk probability and impact assessment	30	8.7	
17	Risk urgency	6	1.7	
18	Technical approach	47	13.7	Dominant
19	Technical approach and assessment	2	0.6	
20	Technical approach and impact assessment	8	2.3	
21	Technical measurement	17	5.0	
22	Technical performance	5	1.5	
23	Technical performance measurement	22	6.4	

*Dominant (more frequent)

5.3.2.6 Systematic Risk Management Process Applied in Building Construction Projects

Table 5.12 summarises the risk management processes carried out in projects. Table 5.12 shows that 88.9% of the respondents claim they carry out risk identification, the same percentage of persons carry out risk assessment and risk response. However, it is vital that effective risk management processes are adopted by construction practitioners and are taken to the very heart of organisations.

Table 5.12: Risk management processes carried out systematically in the project

Risk management processes carried	None	%	Yes	%	No	%	Remark
Risk identification	33	9.6	305	88.9	5	1.5	
Risk assessment	33	9.6	305	88.9	5	1.5	
Risk response	33	9.6	305	88.9	5	1.5	

5.3.2.7 Participant Role in the Risk Management Process

Table 5.13 shows the distribution of the roles of respondents in risk management. The objectives of risk management is to ensure the rapid identification of risks within the building construction project and establish a clear process of assessment, action planning and reporting of the risks identified (Burtonshaw-Gunn, 2009). However, from Table 5.13 it is seen that 28.6% of the respondents were involved in risk assessing, 21.3% were involved in risk identification and 16.9% were involved in risk mitigation. These findings therefore, indicate that quite a number of the respondents are not aware of the importance of managing risk through the life cycle of their projects. Focus and attention is given to the identification of threats and opportunities in their building construction projects as this will enable effective decision making to ensure that risk and opportunities can be quickly assessed at an appropriate level in order to decide whether and how they might proceed with such threats or opportunities. Consequently, threats to the building construction project or other parts of the organisation operations can be eliminated or at least reduced to an acceptable level.

Table 5.13: Distribution of the role in risk management

Role in RM	Frequency	Percent	Remark
None(no response)	114	33.2	Dominant
Risk assessment	98	28.6	
Risk identification	73	21.3	
Risk mitigation	58	16.9	

5.3.2.8 Impact of Risk classification on Building Construction Projects

Table 5.14 analyses the impact of risk on building construction projects. Table 5.14 shows that 60.6% of the respondents indicated that physical risk was low, 60.9% indicated that environmental risk was low. About 52.2% indicated that logistics risk was medium, 63.8% indicated that design risk was low, 72.9% indicated that financial risk was high. About 58.9% indicated that political risk was medium, 84.5% indicated that management risk was low and 56.0% indicated that construction risk was low. Through evaluating the opinion of all the respondents about the risks, it could be ascertained that the level of impact for building construction projects risks in Nigeria is more than intermediate. The hierarchy of risk group impact that influences building construction projects in Nigeria significantly is revealed to be financial risk. This is followed by political and legal risk and then logistics risk. The reason for the high rating of financial risk in building construction projects by contractors might be the influence of financial benefits in executing the project. The influence of this risk on contractors is much more than other group.

Table 5.14: Rating of the impact of risk in building construction companies

Risk group	**Low risk**	**%**	**Medium risk**	**%**	**High risk**	**%**
Physical risk (e.g. supplies of defective materials)	**208**	**60.6**	100	29.2	35	10.2
Environmental risk (e.g. flood)	**209**	**60.9**	92	26.8	42	12.2
Logistics risk (e.g undifined scope of working)	159	46.4	**179**	**52.2**	5	1.5
Design risks (e.g. Defective design, innaccurate quantities, etc.)	**219**	**63.8**	103	30.0	21	6.1
Financial risk (e.g.delayed payment in contract)	4	1.2	89	25.9	**250**	**72.9**
Political and legal risks (e.g. new governmental acts or issues with legislation etc.)	93	27.1	**202**	**58.9**	48	14.0
Mangement risk (e.g Poor resource management)	**290**	**84.5**	49	14.3	4	1.2
Construction risk (e.g. rush bidding)	**192**	**56.0**	66	19.2	85	24.8

5.3.2.9 Influence of Project Actors in Risk Management

Table 5.15 shows the responses according to the size of influence of project actors on risk management. The result on Table 5.15 indicated that 52.8% of the respondents which are client have a very large influence on risk management. About 32.4% of the respondents indicated that the contractor has very large influence on the project and 43.1% of the respondents perceived that the subcontractors have fairly large influence on risk management. The interesting finding from the responses to this question is that, contrary to the views of other project participants, clients have very large influence on risk management. This suggests that clients may well be prepared to improve on risk management.

Table 5.15: Responses on the size of influence of project actors on risk management

Project actors	**Very small**	**%**	**Fairly small**	**%**	**Fairly large**	**%**	**Very large**	**%**
Client	47	13.7	66	19.2	49	14.3	**181**	**52.8**
Contractor	39	11.4	94	27.4	99	28.9	**111**	**32.4**
Subcontractors	60	17.5	94	27.4	**148**	**43.1**	41	12

5.3.2.10 Importance of Risk Management in Phases of Building Construction Project

Table 5.16 summarises the results gotten from respondents based on the importance of risk management in the different phases of the project. Table 5.16 shows that 88.0% of the respondents indicated that risk management was very important in the project inception stage, this was followed by 84.5% who indicated that the risk management was very important at the design stage, 79.9% indicated that risk management was very important at the construction stage of the project and 64.4% opined that risk management was very important at the project inception stage. These results agree that building construction projects generate an important technical and organisational complexity associated with the large range of uncertain events that affect/influence the project and, thus, its success (Taillandier et al, 2015). These results indicate that most of the respondents in Nigeria agree that risk management is an essential requirement for all through the life cycle of building construction projects.

Table 5.16: Importance of risk management in the different phases of the project

Phases of the project	**Unimportant**	**%**	**Not so important**	**%**	**Fairly important**	**%**	**Very important**	**%**
Project inception	0	.00	29	8.5	12	3.5	302	**88.0**
Design	0	.00	1	0.3	52	15.2	290	**84.5**
Construction	0	.00	1	0.3	68	19.8	274	**79.9**
Project completion	2	0.6	18	5.2	102	29.7	221	**64.4**

5.3.2.11 Risk Response Measures in Building Construction Projects

It is important to take into account the dynamic responses from the different stakeholders to risk.Table 5.17 shows the responses based on risk control measurers carried out on projects. According to Table 5.17, loans from financial bodies were the dominant approach used as risk management (35.0%). This was followed by 7.9% who indicated that more labor were hired and the least was that conversion of some irrelevant space, managing all and replacement of materials representing 0.3% respectively. The response from Table 5.17 indicates that construction practitioners in Nigeria do not have sufficient understanding of having an action plan to mitigate risk. Risk response strategies should be considered by the project team and the strategy that is most likely to be effective should be selected for each risk. Specific actions can then be developed to implement each strategy.

Table 5.17: Responses on the solutions to the risk identified

SN	Solutions	Frequency	Percent	Remark
1	Risk identified in projects were managed	1	0.3	
2	Amendments to errors on projects	9	2.6	
3	Conversion of some irrelevant space	1	0.3	
4	Design amendment	11	3.2	
5	Support from experts	10	2.9	
6	It was managed and corrected	1	0.3	
7	Loan from borrowing organizations or persons	120	35.0	Dominant
8	Mobilization of more personnel	1	0.3	
9	More labor were hired	27	7.9	
10	More materials were acquired	9	2.6	
11	Materials were deployed	1	0.3	
12	Materials were changed	12	3.5	
13	Better material were requested	10	2.9	
14	Self-contain was introduced	2	0.6	
15	Equipment hired	9	2.6	
16	The working drawing was amended	6	1.7	
17	Defective supplies were replaced	9	2.6	
18	Defective supplies were returned	10	2.9	
19	Technical approach	4	1.2	
20	Using a good approach of a work plan to prevent risk	6	1.7	
21	Expert were required	10	2.9	
22	Defective designs amended	15	4.4	
23	Good judgement	11	3.2	
24	We borrowed money and employed more skilled labor	10	2.9	
25	We employed more skilled labor	2	0.6	
26	Hire skilled labor and equipment	7	2.0	
27	Revisit project plan	9	2.6	
28	Requested more money from clients	1	0.3	
29	Ensured materials are not stolen	8	2.3	
30	Experts advise	11	3.2	
	Total	343	100.0	

*Dominant (more frequent)

5.3.2.12 Benefits of Risk management in Building Construction Projects

Table 5.18 shows that performing risk management enhances the ability of your company to achieve the project goals of time, cost, and quality (Mean=4.8863) and providing RM software will improve the performance of construction project for your company (Mean=5.0612) were rated above the criterion mean cut off of 3.0. It can be seen from the results in Table 5.18 that majority of the respondents agree that a properly implemented risk management process will enhance the successful completion of building construction projects and thereby make the project more profitable. Therefore, this study aims at establishing a system that will improve the performance of building construction projects in developing countries, without cost and time overruns while achieving optimal quality, through a comprehensive risk management model.

Table 5.18: Mean rating on the benefits risk management

SN	Items	No benefit	Very low benefit	Low benefit	Moderate benefit	High benefit	Very high benefit	Mean	SD	Decision
1	To what extent do you believe that performing RM enhances the ability of your company to achieve the project goals of time, cost, and quality?	0(0.00)	4(1.20)	3(.90)	**150(43.70)**	57(16.60)	129(37.6)	4.8863	0.9712	High
2	To what extent do you believe providing RM software will improve the performance of construction project for your company?	1(.30)	0(.00)	17(5.00)	76(22.20)	114(33.20)	135(39.4)	5.0612	0.9267	High

5.3.3 Identification and Assessment of the Risk Factors

This section of the questionnaire listed seventy nine (79) risks factors identified in literature (see section 3.7) for the participants evaluation within construction projects, according to their experiences based on their likelihood of occurrence and impacts on projects measured on a five-point Likert scale. In order to achieve a consistent quantification, the terms used in the questionnaire to quantify risk likelihood are; improbable, rarely, occasionally, probable and frequent. Also, the terms used to quantify risk impact are; marginal, little, moderate, great and extreme for each risk item (see section 3.9 for description of terms).

5.3.3.1 Risk Likelihood in building construction projects

The descriptive statistics in Table 5.19A, B and C shows respondent mean score on the instrument measuring the risk likelihood associated with building construction projects in Nigeria and the level of awareness of project managers. Each risk in the questionnaire had a scale of 1 to 5 for its criticality. While analysing, numbers in this scale have been grouped together in order to make the understanding of the results easier:

1. Improbable
2. Rarely
3. Occasional
4. Probable
5. Frequent

Not Critical

Intermediate

Critical

Based on the analysis, mean ratings from 3.0 to 5.0 which are the intermediate and critical level respectively will be considered as the accepted criticality level for risk factors in this study. Therefore, the decision cut-off point is 3.0. Any item in which the respondents have a mean score of 3.0 and above is regarded as frequently related (accepted) to the risk likelihood factor. Grand mean score of 3.0 and above indicated that such risk group is frequent. The result however, shows that physical (Mean=**2.8642)**, environmental (Mean=**2.3032)** and design (Mean=**2.8376)** risks were improbable (unlikely but possible).

Table 5.19: Mean rating on the risk likelihood

A:

Risk group	Risk factors	Mean	Std. Deviation	Decision
Physical risk	Supplies of defective materials	3.1691	1.00028	*
	Fluctuation of material prices	3.3003	0.50746	*
	Low productivity of equipment	2.4052	1.02408	
	Shortages of materials required	2.6297	1.13165	
	Insecurity and Theft	3.3557	1.25727	*
	Bribery and Corruption	3.1399	1.53257	*
	Vandalism	2.0496	1.17249	
	Grand Mean	**2.8642**		**Improbable risk level**

Environmental risk	Environmental factors (flood, earthquake, etc.)	1.6268	0.76516	
	Rain effect on construction activities	2.6122	1.42598	
	Hot weather effects on construction activities	2.3848	0.97513	
	Difficulty to access the site (very far, settlements)	2.5889	0.61899	
	Grand Mean	**2.3032**		**Improbable risk level**
Design risk	Defective design (incorrect)	2.242	0.86335	
	Not coordinated design (structural, mechanical, electrical, etc.)	2.3265	1.56107	
	Inaccurate quantities	2.2886	1.34036	
	Lack of consistency between bill of quantities, drawings and specifications	3.3236	1.10961	*
	Rush design	3.5598	1.11151	*
	Shortages of qualified firms	2.5773	1.07565	
	Awarding the design to unqualified designers	3.5452	1.20069	*
	Grand Mean	**2.8376**		**Improbable risk level**

***= probable risk factor (likely to occur regularly)**

The result on Table 5.19B shows that logistic (Mean= **2.9166)**, financial (Mean=**2.9498)** and legal (Mean= **2.3552)** risks were at improbable levels. Delay in equipment delivery, Shortage of equipment required and high competition in bids were frequent risk factor in logistic risk group. Similarly, delayed payment in contracts, incomplete or inaccurate estimates and monopolising of materials due to closure and other unexpected political conditions were rated above the criterion mean cut off to stand as the financial risk factors.

B:

Risk group	Risk factors	Mean	Std. Deviation	Decision
Logistics risk	Shortage of skilled labour	2.7638	1.18454	
	Low productivity of labour	2.379	0.85964	
	Fluctuation of labour prices	2.8601	1.0778	
	Delay in equipment delivery	3.2741	0.75749	*
	Shortage of equipment required	3.519	0.99945	*
	Failure of equipment and unavailability of spare parts	2.4985	0.99377	
	Undefined scope of working	2.8746	0.93598	
	High competition in bids	3.5394	1.42371	*
	Poor communication between the home and field officers (contractors side)	2.519	1.18424	
	Inaccurate project program	2.9388	0.96687	
	Grand Mean	**2.9166**		**Improbable risk level**
Financial risk	Delayed payment in contracts	4.105	0.44663	*
	Incomplete or inaccurate estimates	3.6006	0.71386	*
	Incomplete documentation for the delivery of the project	2.7434	0.88096	*
	Financial attraction of project to investors	3.1924	0.61961	
	Financial failure of the contractor	2.9417	0.95028	
	Unmanaged cash flow	2.6793	0.74677	
	Exchange rate fluctuation	2.3236	1.21043	
	Monopolizing of materials due to closure and other unexpected political conditions	3.3382	1.32538	*
	Difficulty to get permit	2.379	1.37302	
	Inflation and sudden changes in prices	2.1953	1.06775	
	Grand Mean	**2.9498**		**Improbable risk level**
Legal risk	Legal disputes during the construction phase among the parties of the contract	2.2682	0.89724	
	Delayed dispute resolutions	2.5219	0.85084	
	Requirement to use local labour	2.895	1.34232	
	Ineffective enforcement of rules and regulation	2.5977	1.07399	

Frequent changes and modification in law	1.8192	0.97151	
No specialized arbitrators to help settle fast	2.0292	1.00249	
Grand Mean	**2.3552**		**Improbable risk level**

***= probable risk factor (likely to occur regularly)**

The result on Table 5.19C indicated that construction (Mean=2.9229), political (Mean=2.8496) and management (Mean=2.7761) risks were improbable. A close look at the Table 4.19C shows that ineffective use of information technology and decision making techniques, improper construction methods, insufficient understanding and use of insurance policy, low salaries and lack of incentives and motivations for project personnel and unsuitable leadership style were probable construction risk factors. Similarly, unqualified decision makers, instability in project governance, lack of transparency and political orientation were probable political risk factors. Finally, failure to provide documents and information on time, poor site management and supervision and poor communication between involved parties were rated as probable management risk factors.

C:

Risk group	**Risk factors**	**Mean**	**Std. Deviation**	**Decision**
Construction risk	Rush bidding	2.6531	0.97889	
	Lack of experienced people involved in technical studies, estimating, and scheduling	2.8717	1.14498	
	Lack of database in estimating activity duration and cost	2.8484	0.87546	
	Lack of coordination and communication between various parties	2.9125	0.89733	
	Ineffective use of information technology and decision making techniques	3.0671	1.23953	*
	Inadequate overall company structure	2.8688	0.89687	
	Improper construction methods	3.1691	0.98556	*
	improper quality, health, and safety management	2.7901	1.25992	
	Insufficient understanding and use of insurance policy	3.2157	1.16734	*
	Low salaries and lack of incentives and motivations	3.1429	1.1265	*

	for project personnel			
	Unsuitable leadership style	3.0875	1.03078	*
	Shortage of qualified and specialised companies	2.6793	1.44967	
	Unavailability of specialised companies for sophisticated work packages	2.7638	0.95187	
	Gaps between the implementation and the specification due to misunderstanding and specification	2.2391	0.93094	
	Undocumented change orders	2.7726	1.22147	
	Lower work quality in presence of time constraints	2.9825	0.89491	
	Design changes	4.102	1.0807	*
	Actual quantities differ from the contract quantities	2.4461	0.91567	
	Grand Mean	**2.9229**		**Improbable risk level**
Political risk	Unqualified decision makers	3.4461	1.20033	*
	Instability in project governance	3.2886	1.22883	*
	Lack of transparency	3.4257	1.12631	*
	Political orientation	3.2128	0.7364	*
	New governmental acts or legislations	2.6443	0.77725	
	Unstable security circumstances (invasion)	2.035	1.03107	
	closure	1.895	1.04605	
	Grand Mean	**2.8496**		**Improbable risk level**
Management risk	Ambiguous planning due to project complexity	2.7055	1.14358	
	Resource management	2.5831	0.64296	
	Changes in management ways	2.4373	0.90224	
	Unavailability of contractors pre-qualification system	2.688	1.28603	
	Unqualified owners representatives	2.4577	0.99874	
	Slowness of the owners decision making process causing suspension of work	2.4227	1.36122	
	Information unavailability (include uncertainty)	2.8076	1.09398	
	Failure to provide documents and information on time	3.2099	1.15075	*

Poor site management and supervision	3.2362	1.0258	*
Poor communication between involved parties	3.2128	0.7364	*
Grand Mean	**2.7761**		**Improbable risk level**

***= probable risk factor (likely to occur regularly)**

5.3.3.2 Risk Impact in building construction projects

The descriptive statistics in Table 5.20A, B and C shows respondent mean score on the instrument measuring the risk impact associated with building construction projects in Nigeria and the level of awareness of project managers. The decision cut-off point is 3.0. Any item in which the respondents have a mean score of 3.0 and above is regarded as significant related (accepted) to the risk impact factor. Grand mean score of 3.0 and above indicated that such risk group is significant. Table 5.20A shows that physical (Mean=3.2707) and design (Mean=3.3823) were significant risk groups while environmental (Mean=2.5736) was negligible risk group. The Table 4.31A further shows that supplies of defective materials, fluctuation of material prices, low productivity of equipment, shortages of materials required and insecurity and theft were rated as significant physical risk factors. Only environmental factors (flood, earthquake, etc.) were rated as a significant environmental risk factor. Finally, defective design (incorrect), not coordinated design (structural, mechanical, electrical, etc.), inaccurate quantities, lack of consistency between bill of quantities, drawings and specifications, rush design and awarding the design to unqualified designers were rated above the criterion mean as design risk factors.

Table 5.20: Mean rating on the risk impact

A:

Risk group	**Risk factors**	**Mean**	**Std. Deviation**	**Decision**
Physical risk	Supplies of defective materials	4.0816	0.43835	*
	Fluctuation of material prices	3.0525	0.75133	*
	Low productivity of equipment	3.2799	0.85691	*
	Shortages of materials required	3.0466	1.21546	*
	Insecurity and Theft	3.7376	0.58835	*
	Bribery and Corruption	2.9883	1.40587	

	Vandalism	2.7085	1.39217	
	Grand Mean	**3.2707**		**Significant risk level**
Environmental risk	Environmental factors (flood, earthquake, etc.)	3.5452	1.35622	*
	Rain effect on construction activities	2.6997	1.28654	
	Hot weather effects on construction activities	2.2915	0.73119	
	Difficulty to access the site (very far, settlements)	1.758	0.99254	
	Grand Mean	**2.5736**		**Negligible risk level**
Design risk	Defective design (incorrect)	4.0058	0.68822	*
	Not coordinated design (structural, mechanical, electrical, etc.)	3.5248	0.63416	*
	Inaccurate quantities	3.2886	0.96188	*
	Lack of consistency between bill of quantities, drawings and specifications	3.1195	0.95834	*
	Rush design	3.0554	0.88514	*
	Shortages of qualified firms	2.7551	1.6253	
	Awarding the design to unqualified designers	3.9271	0.82572	*
	Grand Mean	**3.3823**		**Significant risk level**

=Significant risk factor (Serious threat on project)

Table 5.20B shows that logistic (Mean=3.2863), financial (Mean=3.4930), and legal (Mean=3.15598) risks were significant risk groups. Specifically, all the risk factors or dimensions of logistic risk were rated above criterion mean (significant risk level), similar result was obtained in terms of financial risk. Legal disputes during the construction phase among the parties of the contract, delayed dispute resolutions and frequent changes and modification in law were identified as the significant legal risk factors.

B:

Risk group	**Risk factors**	**Mean**	**Std. Deviation**	**Decision**
Logistics risk	Shortage of skilled labour	3.2945	0.9260	*
	Low productivity of labour	3.1137	0.72258	*
	Fluctuation of labour prices	3.0962	0.80173	*
	Delay in equipment delivery	3.4315	0.77259	*
	Shortage of equipment required	3.5394	0.78959	*

	Failure of equipment and unavailability of spare parts	3.2711	0.79432	*
	Undefined scope of working	3.2012	0.76686	*
	High competition in bids	3.3382	1.11969	*
	Poor communication between the home and field officers (contractors side)	3.1341	0.99094	*
	Inaccurate project program	3.4431	0.69804	*
	Grand Mean	**3.2863**		**Significant risk level**
Financial risk	Delayed payment in contracts	3.8688	0.58012	*
	Incomplete or inaccurate estimates	3.8222	0.64471	*
	Incomplete documentation for the delivery of the project	3.3994	0.98569	*
	Financial attraction of project to investors	3.5306	1.03651	*
	Financial failure of the contractor	3.7376	0.47874	*
	Unmanaged cash flow	3.6385	0.70332	*
	Exchange rate fluctuation	3.0700	0.80988	*
	Monopolizing of materials due to closure and other unexpected political conditions	3.5248	1.06998	*
	Difficulty to get permit	3.0466	0.80795	*
	Inflation and sudden changes in prices	3.2915	1.03851	*
	Grand Mean	**3.4930**		**Significant risk level**
Legal risk	Legal disputes during the construction phase among the parties of the contract	3.7318	1.02786	*
	Delayed dispute resolutions	3.6356	1.11272	*
	Requirement to use local labour	2.5743	0.93948	
	Ineffective enforcement of rules and regulation	2.9854	0.7816	
	Frequent changes and modification in law	3.1429	0.87526	*
	No specialized arbitrators to help settle fast	2.8659	1.13146	
	Grand Mean	**3.15598**		**Significant risk level**

=Significant risk factor (Serious threat on project)

Table 5.20C shows that construction (Mean=**3.2690**) political (Mean=**3.5360**) and management (Mean=**3.3732**) risks were identified as significant risk groups. rush bidding, lack of experienced people involved in technical studies, estimating, and scheduling, Lack of coordination and communication between various parties, ineffective use of information technology and decision making techniques, improper construction methods, proper quality, health, and safety management, low salaries and lack of incentives and motivations for project personnel, shortage of qualified and specialised companies, unavailability of specialised companies for sophisticated work packages, gaps between the implementation and the specification due to misunderstanding and specification, undocumented change orders, lower work quality in presence of time constraints and actual quantities differ from the contract quantities were identified as significant risk factors. Unqualified decision makers, instability in project governance, lack of transparency, political orientation, new governmental acts or legislations and unstable security circumstances (invasion) were identified as political risk factors. Ambiguous planning due to project complexity, resource management, unqualified owners representatives, slowness of the owners decision making process causing suspension of work, information unavailability (include uncertainty), failure to provide documents and information on time, poor site management and supervision and poor communication between involved parties were rated as management risk factors.

C:

Risk group	**Risk factors**	**Mean**	**Std. Deviation**	**Decision**
Construction risk	Rush bidding	3.5481	0.76655	*
	Lack of experienced people involved in technical studies, estimating, and scheduling	3.8017	0.57866	*
	Lack of database in estimating activity duration and cost	3.3965	0.81663	
	Lack of coordination and communication between various parties	3.6356	0.74819	*
	Ineffective use of information technology and decision making techniques	3.5569	0.7544	*
	Inadequate overall company structure	3.1662	0.87112	
	Improper construction methods	3.3324	0.78381	*
	Proper quality, health, and safety management	2.9388	1.01122	
	Insufficient understanding and use of insurance policy	2.6152	1.19355	
	Low salaries and lack of incentives and motivations for project personnel	3.3265	0.61991	*
	Unsuitable leadership style	2.7405	0.83405	
	Shortage of qualified and specialised companies	3.4052	0.60859	*
	Unavailability of specialised companies for sophisticated work packages	3.5831	0.59082	*

	Gaps between the implementation and the specification due to misunderstanding and specification	3.5685	0.79129	*
	Undocumented change orders	2.5714	0.89834	
	Lower work quality in presence of time constraints	3.6443	0.58391	*
	Design changes	2.723	1.11172	
	Actual quantities differ from the contract quantities	3.2886	0.93413	*
	Grand Mean	**3.2690**		**Significant risk level**
Political risk	Unqualified decision makers	3.7026	0.77548	*
	Instability in project governance	3.6356	0.91359	*
	Lack of transparency	3.8192	0.61367	*
	Political orientation	3.8222	0.76882	*
	New governmental acts or legislations	3.4344	1.14232	*
	Unstable security circumstances (invasion)	3.7843	1.04579	*
	Closure	2.5539	1.39627	
	Grand Mean	**3.5360**		**Significant risk level**
Management risk	Ambiguous planning due to project complexity	3.9388	1.02557	*
	Resource management	3.3294	1.09461	*
	Changes in management ways	2.8950	1.26146	
	Unavailability of contractors pre-qualification system	2.9679	0.96828	
	Unqualified owners representatives	3.1924	1.08593	*
	Slowness of the owners decision making process causing suspension of work	3.0787	0.98062	*
	Information unavailability (include uncertainty)	3.242	1.05536	*
	Failure to provide documents and information on time	3.4606	1.14863	*
	Poor site management and supervision	3.9155	0.42076	*
	Poor communication between involved parties	3.7114	0.51986	*
	Grand Mean	**3.3732**		**Significant risk level**

=Significant risk factor (Serious threat on project)

Having identified the critical risk factors affecting building construction projects based on their likelihood of occurrence and impact on building construction projects (Tables 5.19 and 5.20), it was therefore, necessary to highlight the significance and relationship between the impact and likelihood of risk factors. Linear regression analysis was employed and the factors of risk impact were regressed against the factors of likelihood.

According to Venkatesan et al (2015) regression analysis is used to generate an equation to describe the statistical relationship between one or more predictors and the response variable and to predict new observations. Regression generally uses the least squares method which derives the equation by minimizing the sum of the squared residuals (Venkatesan et al, 2015). The computations from the analysis generated the following results;

a) R^2 and Adjusted R^2 values: According to Minitab (2015) R^2 is the percentage of response variable variation that is explained by its relationship with one or more predictor variables. Usually, the higher the R^2, the better the model fits your data. R^2 is always between 0 and 100%. Furthermore, Minitab (2015) describes the Adjusted R^2 as the percentage of response variable variation that is explained by its relationship with one or more predictor variables, adjusted for the number of predictors in the model. This adjustment is important because the R^2 for any model will always increase when a new term is added.
b) Standard error: According to Weisstein (2015), the standard error is an estimate of the standard deviation of a statistic.
c) t-value: According to Minitab (2015) the t-value is a test statistic for t-tests that measures the difference between an observed sample statistic and its hypothesized population parameter in units of standard error. A t-test compares the observed t-value to a critical value on the t-distribution with (n-1) degrees of freedom to determine whether the difference between the estimated and hypothesized values of the population parameter is statistically significant (Minitab, 2015).
d) ANOVA: Analysis of variance (ANOVA) is a statistical tool for studying the relation between a response variable and or more explanatory and predictor variable (Neter et al. 1996).
e) Sum of squares: The sum of squares represents a measure of variation or deviation from the mean (Minitab, 2015). Consequently, it is calculated as a summation of the squares of the differences from the mean and the calculation of the total sum of squares considers both the sum of squares from the factors and from randomness or error (Minitab, 2015).
f) Degree of freedom: The degree of freedom (df) of an estimate is the number of independent piece of information on which the estimate (Lane, 2015). In general, the degrees of freedom for an estimate is equal to the number of values

minus the number of parameters estimated through to the estimate in question (Lane, 2015). For example, to estimate the population variance, one must first estimate the population mean. Therefore, if the estimate of variance is based on N observations, there are N-1 degrees of freedom (Lane, 2015).

g) *F* statistic: According to Dielman (2005), a measure of how well the regression line fits the data, is provided by the *F* statistics. The *F* statistics is a value you get when you run an ANOVA test or a regression analysis to find out if the means between two populations are significantly different. Consequently, Dielman (2005) reports that the *F* statistics is computed as:

$$F=\frac{MSR}{MSE} \qquad 1$$

Where *MSR* is the mean square due to the regression, or the regression sum of squares divided by its degree of freedom. *MSE* is the mean square due to error, or the error sum of square divided by its degree of freedom.

5.3.3.3: Relationship between risk likelihood and risk impact

Table 5.21 shows that the mean impact was 3.3028, with Standard Deviation (SD) of 0.43160 while the mean rating on Likelihood was 2.8132 with an SD of 0.49486. Table 5.22 shows that r-value of 0.204 indicated a strong influence of likelihood of risk to its impact. The Adjusted r^2-value of 0.029 indicates roughly the contribution of 50.0% to risk impact of the independent variable, risk likelihood. The regression equation in Table 5.23 shows that any increase in value of risk likelihood will yield a resultant increase in the value of the risk impact. Furthermore, from Table 5.24 indicates that likelihood of risk has a significant influence on the impact ($F1, 77=3.344$, $p<.05$). (See appendix I)

Table 5.21: Summary of linear regression analysis on the relationship between risk likelihood and risk impact

Descriptive Statistics

	Mean	Std. Deviation	N
Impact	3.3028	0.43160	79
Likelihood	2.8132	0.49486	79

Table 5.22: Model Summary

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.204[a]	0.042	0.029	0.42525

a. Predictors: (Constant), Likelihood

Table 5.23: Regression Coefficients[a] of the risk likelihood and risk impact

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.802	.278		10.084	.000
	Likelihood	0.178	0.097	0.204	1.829	.071

a. Dependent Variable: Impact

I_R= 2.802+.178L_R

Table 5.24: ANOVA of the risk likelihood and risk impact

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	0.605	1	0.605	3.344	0.071[b]
	Residual	13.925	77	0.181		
	Total	14.530	78			

a. Dependent Variable: Impact

b. Predictors: (Constant), Likelihood

Consequently, Table 5.25 shows that profession ($F3, 336=1.365$, $p=.253$) and project role ($F3, 336=.498$, $p=.684$) do not have significant effect on their mean rating on risk likelihood respectively. (See appendix I).

Table 5.25: Summary of factorial ANOVA on the effects of professional and project role on risk likelihood.

Source of variation	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	168.684[a]	6	28.114	0.747	0.612
Intercept	726430.574	1	726430.574	19306.744	0
Profession	154.025	3	51.342	1.365	0.253
Role	56.241	3	18.747	0.498	0.684
Error	12642.249	336	37.626		
Total	1098225.000	343			
Corrected Total	12810.933	342			

The line graph drawn in Figures 5.2 shows clearly that based on profession, project managers evaluate building construction risk more on likelihood of occurrence than other groups. It also demonstrates that this evaluation is followed by the group architects then civil engineers. Finally, on the likelihood of risk occurring, quantity surveyors evaluated building construction risk less compared to other groups. In Figure 5.3, based on their role in building construction projects, it clearly shows that clients evaluate building construction risk more on likelihood of occurrence than other groups. This is followed by others which represents consultants, engineers etc. Contractors and sub-contractors follow respectively.

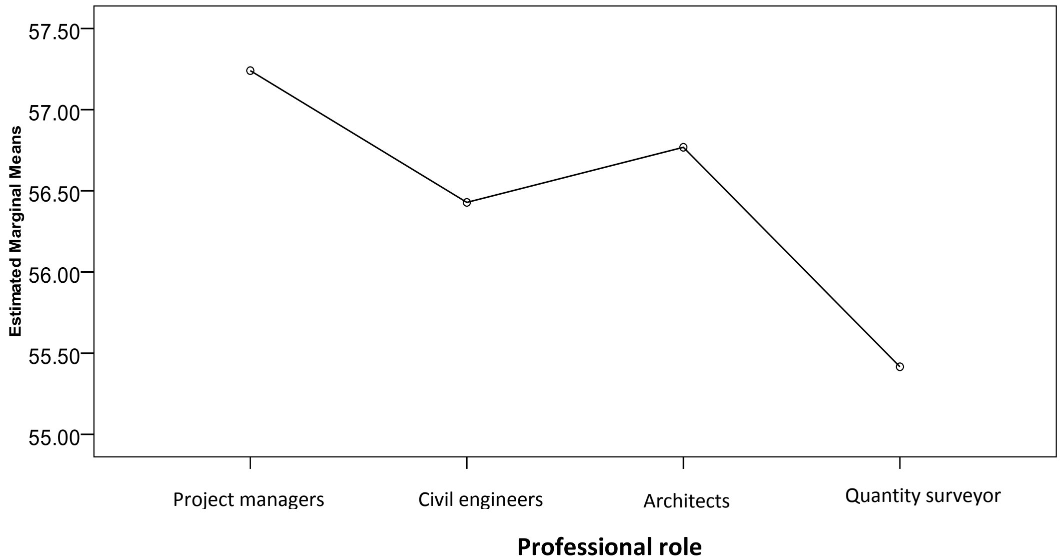


Figure 5.2: Mean rating of risk likelihood based on professional role

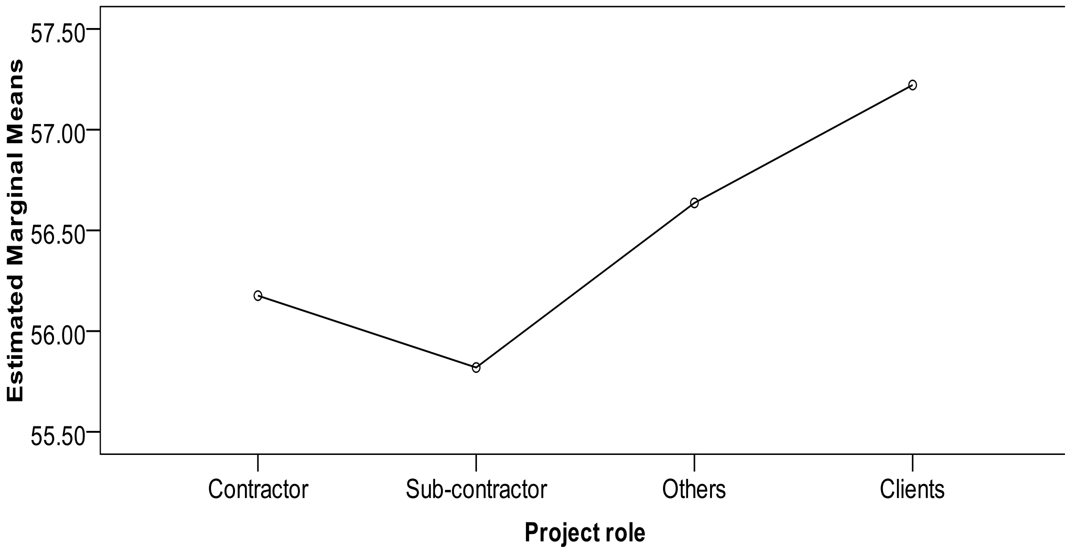


Figure 5.3: Mean rating of risk likelihood based on project role

Table 5.26 shows that profession (F3, 336=.967, p=.409) and project role (F3, 336=.393, p=.758) do not have significant effect on their mean rating on risk impact respectively (See appendix I). The line graph drawn in Figures 5.4 shows clearly that based on profession, project managers evaluate building construction risk more on impact than other groups. It also demonstrates that this evaluation is followed by the group architects then civil engineers. Finally, on the impact of risk, quantity surveyors evaluated building construction risk less compared to other groups. Figure 5.5, shows that based on their role in building construction projects, clients evaluate building construction risk more on impact than other groups. This is followed by others which represents consultants, engineers etc. Contractors and sub-contractors follow respectively.

Table 5.26: Summary of factorial ANOVA on the effects of professional role and project role on risk impact

Source of variation	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	94.629[a]	6	15.771	0.559	0.763
Intercept	999515.272	1	999515.272	35449.904	0.000
Profession	81.759	3	27.253	0.967	0.409
Role	33.202	3	11.067	0.393	0.758
Error	9473.570	336	28.195		
Total	1507771.000	343			
Corrected Total	9568.198	342			

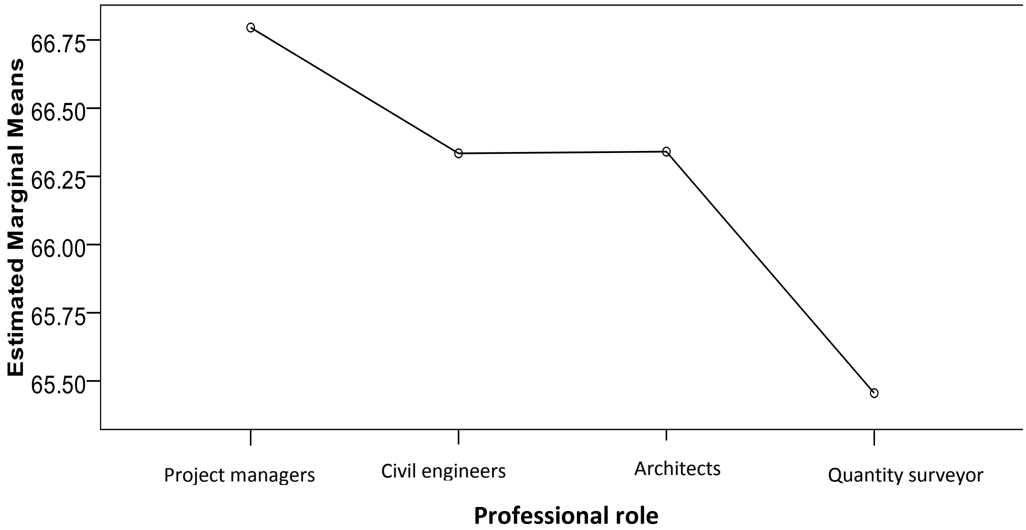


Figure 5.4: Mean rating on risk impact based on professional role

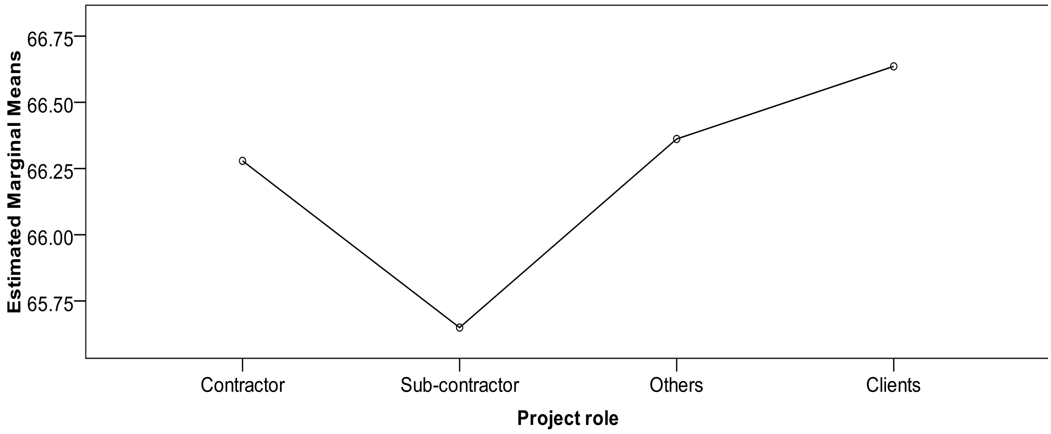


Figure 5.5: Mean rating on risk impact based on project role

The consequences of decision in building construction projects can have a major impact on the project success or failure (in terms of cost, time, and quality), and as well as on environment (injured people or fatalities, environmental damage, political consequences, etc.) (Taillandier et al, 2015). Moreover, the decisions have to take into account different types of stakeholders: client, contractors, subcontractors, user, etc. These stakeholders may have different objectives (project cost, quality/performance, etc.), different views on the project and different roles and responsibilities in the project (decision-maker, user, etc.).

From the results in the line graphs highlighted, the different parties involved in building construction project have different perceptions of the risk factors associated with their project and they are likely to have different objectives or at least different priorities for their objectives. For contractor and sub-contractor, their main objective is usually profit whereas for the client position it is more significant and others who represents consultant, engineers etc. usually have a mixture of these objectives. The difference in viewpoints of the clients in evaluating the likelihood of risks occurring and the impact more critically compared to others can be as a result from various reasons. Research by Taillandier et al. (2015) suggests that clients place more importance on quality and time followed by cost whereas for project managers, there is more emphasis on time, cost, followed by quality. For architects and quantity surveyors however, equal importance is placed on time and quality with little regard for cost. It is therefore, not surprising that the perceptions on both risk likelihood and impact are different for all parties.

The type of personality of the clients, as people who are employed to work in a governmental organisation (according to the regulations and defined responsibilities) can be considered less daring and adventurous compared to the other three groups. In building construction projects, the contractor is the one who copes with the risk and the client pays for it. As a result, because the client is not in the group who deals directly with the risk associated with the project and due to their lower level of their expertise; influences of risks may worry them more and consequently they assess the risk as more critical. Looking at the other groups in the diagram, it is not only the mentality which determines the differences between the four groups but there might also be other factors that may affect their opinion about the level of criticality of the risks. These may include task perspective, which deals with the work breakdown structure and organisation perspective, which considers the final outcome of a project (Andersen, 2015). The dissimilarity between them can be from the extent to which they are influenced by building construction risks. As reported in Akintoye and Macleod (1997), risks perceptions are also influenced by educational backgrounds, practical experience, individual characteristics and availability of information. These factors are likely to be responsible for project managers perceiving the likelihood and impact of risks more critical than the other groups.

5.4 Chapter Summary

This chapter analysed the quantitative data collected for this research through questionnaire. Three sections of the questionnaire were analysed through different methods and the results were presented. Each phase has contributed to the development of an important part of this thesis in order to systematically achieve the research objectives. Therefore, this chapter summarized and discussed the backgrounds and characteristics of construction professionals who took part in these phases. In addition, it represented the responses that have been given in various phases of the field work, with particular emphasis on the survey phase. Therefore, in the next chapter, a Bayesian belief network model will be developed for a building construction project where a cause and effect diagram among risk will be constructed. Risk probability will be obtained by calculating the joint conditional risks, and major risk, which affects project performance, will also be identified.

CHAPTER SIX: APPLICATION OF THE BAYESIAN BELIEF NETWORK TO SUPPORT RISK MANAGEMENT OF BUILDING CONSTRUCTION PROJECTS

6.0 Chapter Introduction

Bayesian belief network (BBN) is a tool that enables the researcher to exploit different information, deterministic or probabilistic, emerging from real world scenario, under condition of complex relations between different variables (Trucco, Cagno, Ruggeri and Grande, 2008). In this chapter, the BBN modelling process will be applied to support risk assessment in building construction projects. The theoretical foundation of BBN has been discussed in section 2.7. Furthermore, guidelines for linking adverse events in construction risk scope under the knowledge boundary of participants in building construction organisation are explained in section 2.7.2. In this chapter, the proposed risk management frame work is implemented to explain interactions between risk factors (see section 2.8 for risk management framework for building construction projects). Detail of the rationale of process design will be explained in the next section, after which the risk management procedure using a Bayesian belief network is applied to support risk management in building construction projects in Nigeria.

6.1 Rationale for Designing Bayesian Belief Network for Building Construction Project Risk Modelling Process

According to Bower (1994), "the very process of eliciting the data (in risk analysis) is vital: often, the process itself appears to be more useful than the actual output of the analysis. The data-collection process should stimulate communication in an open atmosphere in which possible problems can be admitted, and precautionary actions examined, while the essential optimism in the project team is preserved".

The design of the process is essential because it should be able to stimulate and improve the participating of experts by sharing their perceptions with their stakeholders. The available Bayesian network processes is challenged by requirements of implementing Bayesian belief network to support risk analysis, as was explained in Section 2.7. With lead from Bower (1994), the structure of the modelling process that is able to manage the challenges in this context, six useful sources are modified for this study. This is discussed as follows;

1. The issues of concern to problem structuring for Bayesian belief network are defined by four criteria, as explained in Section 2.7.2.1 these will be used to transform the general casual map into Bayesian belief network format.
2. Model validity under the assumption of no true data being available is reviewed in table 2.4 before proposing the essential criteria for model validation. These criteria are also taken into the process in order to define the validating model, to ensure that the outcomes of the model can be used to support risk analysis with confidence.
3. The techniques of aiding experts to identify systemic risks in the problem structuring process are also explored, in order to investigate the perceptions of building construction project experts before selecting the suitable techniques and approaches that support the problem structuring process.
4. The Bayesian belief network model framework for building construction project is developed in section 2.7.2 and is used to provide guidelines for linking adverse events in building construction project.
5. The approach of eliciting probability from experts' knowledge has been developed by the researcher (see section 5.3.3)
6. Many methods and techniques are reviewed from the literature and suitable options for particular stages are selected by aiming to use the simplest and most transparent methods.

6.2 An Application of Project Risk Management Procedure in the Nigerian Building Construction Industry Using a Bayesian Belief Network

A risk management framework for building construction projects in developing countries was developed in section 2.8. The proposed framework was applied to support risk management of building construction projects in Nigeria. This section explains the procedure that was used in applying BBN under the following main themes: identification of risk factors; qualitative risk assessment for BBN; construction of the BBN model; and risk control (sensitivity analysis).

6.2.1 Identification of Risk in Building Construction Projects in Nigeria

Risk identification forms an integral part of risk management as discussed in section 2.5.2. The procedure for identifying risks for building construction projects in Nigeria began with the review of literature on risk factors affection building construction projects in developing countries as discussed in section 3.3. Through this process, a set of seventy nine (79) risk factors was identified (see section 3.7 and figure 3.9). For the purposes of identifying which of the risks are influential in the Nigerian construction industry, a questionnaire survey was conducted in three states in Nigeria (see section 4.4.2). To determine the most significant risk factors affecting building construction projects in Nigeria, as perceived by building contractors, subcontractors and clients, descriptive statistics of the mean (the average of all risk levels of each risk factors in all project surveyed) were used (see section 5.3.3). A criticality decision cut-off point of 3.0 and above for risk likelihood was the criteria adopted and merged with the impact of risks which then reduced the risk factors to a total of 27 variables as shown in Table 6.1. These 27 risk factors were identified to cause cost overruns, time overruns and quality problems in building construction projects.

Table 6.1: The 27 significant risk items in building construction projects

Risk category	***Risk factors***	***Risk likelihood (MR)***	***Risk Impact (MR)***	***Remarks***
Physical risk	*Supplies of defective materials*	*3.1691*	*4.0816*	*Internal*
	Fluctuation of material prices	*3.3003*	*3.0525*	*External*
	Insecurity and theft	*3.3557*	*3.7376*	*Internal*
	Bribery and corruption	*3.1399*	*2.9883*	
Design risk	*Lack of consistency between bill of quantities, drawing and specifications*	*3.3236*	*3.1195*	*Internal*
	Rush design	*3.5598*	*3.0554*	*Internal*
	Awarding the design to unqualified designers	*3.5452*	*3.9271*	*Internal*
Logistics risk	*Delay in equipment delivery*	*3.2741*	*3.4315*	*Internal*
	Shortage of equipment required	*3.519*	*3.5394*	*Internal*
	High competition in bids	*3.5394*	*3.3382*	*Internal*
Financial risk	*Delayed payment in contracts*	*4.105*	*3.8688*	*Internal*
	Incomplete and inaccurate estimates	*3.6006*	*3.8222*	*Internal*
	Financial attraction to project investors	*3.1924*	*3.5306*	*Internal*
	Monopolizing of materials due to closure and unexpected political conditions	*3.3382*	*3.5248*	*External*
Construction risk	*Ineffective use of information technology and decision*	*3.0671*	*3.5569*	*Internal*

	making techniques			
	Improper construction methods	*3.1691*	*3.3324*	*Internal*
	Insufficient understanding and use of insurance policy	*3.2157*	*2.6152*	*External*
	Unsuitable leadership style	*3.0875*	*2.7405*	*Internal*
	Low salaries and lack of incentives and motivations for project personnel	*3.1429*	*3.3265*	*Internal*
	Design changes	*4.102*	*2.723*	*Internal*
Political risk	*Unqualified decision makers*	*3.4461*	*3.7026*	*Internal*
	Instability in project governance	*3.2886*	*3.6356*	*Internal*
	Lack of transparency	*3.4257*	*3.8192*	*Internal*
	Political orientation	*3.2128*	*3.8222*	*External*
Management risk	*Failure to provide documents and information on time*	*3.2099*	*3.4606*	*External*
	Poor site management and supervision	*3.2362*	*3.9155*	*Internal*
	Poor communication between involved parties	*3.2128*	*3.7114*	*Internal*

**** MR (Mean Rating)***

Out of the 9 risk categories identified in section 3.7, the 27 significant risk factors fall within 7 of the categories as shown in table 6.1 above. As shown in the table, the minimum mean rating (MR) identified for risk likelihood was 3.0671 whereas the maximum MR was 4.105 out of a possible 5. Out of the 27 risk factors, 21 were considered to be internal which suggests they are within the direct control of the contractor. The remaining 6 were considered to be external which originate from areas beyond the range of the contractor’s control (see section 3.6).

6.2.2 Risk assessment for a Bayesian Belief Network

Consequently, in adopting the Bayesian belief network for risk assessment, the risk level of each risk factor identified in a building construction project is measured and the dataset is modified for a Bayesian belief network analysis where the severity of the risk is determined by Kuo (1998) using the degree of loss and the probability of occurrence.

$$\text{Risk} = (\text{the degree of loss}) \times (\text{the probability of occurrence}) \qquad (1)$$

However, this equation is argued to be inadequate since it does not differentiate between risks that are highly likely to occur but would have low impact and those that are very unlikely to occur but would have disastrous impact if they did.

The RAM uses five nonlinear scales for likelihood and a different five nonlinear scales for impact to distinguish between the two matrix dimensions as shown in Figure 3.16 (P. 103). Thus, if two risk factors were to occur; one has a frequent likelihood but of marginal impact; and the other has an improbable likelihood but with an extreme consequence. The first and the second risk factors will rank (21) and (5) respectively in the RAM as shown in figure 3.17, hence, the two risk factors are differentiated.

The categorisation and prioritisation of the risk acceptability matrix (RAM), with the Y axis describing the likelihood of risk occurrence while the X axis the impact. The Y axis ranges from improbable to frequent while the X axis ranges from marginal to extreme. The RAM ranks risk factors to twenty five (25) ranks according to their perceived significance. According to this matrix, the risk factors are categorized into three groups as illustrated in Figure 3.16, specifically: unacceptable risks (red condition); undesirable risks (amber condition) and acceptable risks (green condition). Further, the matrix provides threshold values to acceptability of risks as shown in Table 6.2 (see "Chapter Three" (P. 97 to P. 102) for more discussion).

Table 6.2: Key to acceptance of risk

Rank	**RISK**	**CATEGORY**	**ACTION REQUIRED**
1 - 9	High risk (R3)	Unacceptable	Must eliminate or transfer risk
10 - 18	Medium Risk (R2)	Undesirable	Attempt to avoid, reduce or transfer risk
19-25	Low Risk (R1)	Acceptable	Retain and manage risk

Table 6.3 shows the risk assessment results of risk factors using the risk acceptability matrix (RAM). As shown in Table 6.3, the risk acceptability matrix categorises and prioritises the risk factors presented based on the assessment of their likelihood of occurring and impact on project performance when they occur. Based on the prioritisation matrix, the risk factors are ranked based on their priorities from 1 to 25

where 1 represents high risk factors and with 25 being low. The risk factors are then categorized from R1 to R3, where R3 represents high risk factors, R2 medium risk, and R1 low risk factors to determine the action required for managing such risks.

The causes of poor performance in building construction projects has been measured using the risk likelihood and risk impact indices of each identified risk factor and placed in the appropriate cell within the RAM based on the perception of respondents. For example, the assessment of 'supplies of defective materials' in Table 6.3 has been represented appropriately through the RAM. Table 6.3 suggests that 'supplies of defective materials' is placed on the "occasional" likelihood row within the RAM whereas the "great" for impact is positioned in the suitable column. Therefore, the two risk attributes will meet up within the red colour (R3) in the matrix, precisely in the cell number eight (8) as illustrated in Figure 3.17. This meant that the "supplies of defective material" is ranked eighth in criticality by means of the RAM according to construction practitioners of building construction projects as illustrated in Table 6.3. The same assessment was carried out for other risk factors by categorising and prioritising and the results have been demonstrated in Table 6.3.

The results from Table 6.3 also reveals that, the most critical risk that affect building construction performance in Nigeria is "supplies of defective material" and is considered as an unacceptable risk factor as illustrated in Table 6.2. This is followed by "delayed payments in contract" which is considered undesirable as well as other risk factors identified in Table 6.3 since it falls between 10 and 18 in rank. Further, the Table 6.2 provides some actions which have to be taken to manage this category of risk.

Table 6.3: Assessment of risk factors using RAM

Risk category	***Risk factors***	***Risk likelihood***	***Risk Impact***	***RAM***	
				Ranking	***Category***
Physical risk	*Supplies of defective materials*	*Occasionally*	*Great*	*8*	*R3*
	Fluctuation of material prices	*Occasionally*	*Moderate*	*12*	*R2*
	Insecurity and theft	*Occasionally*	*Moderate*	*12*	*R2*
	Bribery and corruption	*Occasionally*	*Little*	*18*	*R2*
Design risk	*Lack of consistency between bill of quantities, drawing and specifications*	*Occasionally*	*Moderate*	*12*	*R2*
	Rush design	*Occasionally*	*Moderate*	*12*	*R2*

	Awarding the design to unqualified designers	*Occasionally*	*Moderate*	*12*	*R2*
Logistics risk	*Delay in equipment delivery*	*Occasionally*	*Moderate*	*12*	*R2*
	Shortage of equipment required	*Occasionally*	*Moderate*	*12*	*R2*
	High competition in bids	*Occasionally*	*Moderate*	*12*	*R2*
Financial risk	*Delayed payment in contracts*	*Probable*	*Moderate*	*11*	*R2*
	Incomplete and inaccurate estimates	*Occasionally*	*Moderate*	*12*	*R2*
	Financial attraction to project investors	*Occasionally*	*Moderate*	*12*	*R2*
	Monopolizing of materials due to closure and unexpected political conditions	*Occasionally*	*Moderate*	*12*	*R2*
Construction risk	*Ineffective use of information technology and decision making techniques*	*Occasionally*	*Moderate*	*12*	*R2*
	Improper construction methods	*Occasionally*	*Moderate*	*12*	*R2*
	Insufficient understanding and use of insurance policy	*Occasionally*	*Little*	*18*	*R2*
	Unsuitable leadership style	*Occasionally*	*Little*	*18*	*R2*
	Low salaries and lack of incentives and motivations for project personnel	*Occasionally*	*Moderate*	*12*	*R2*
	Design changes	*Probable*	*Little*	*16*	*R2*
Political risk	*Unqualified decision makers*	*Occasionally*	*Moderate*	*12*	*R2*
	Instability in project governance	*Occasionally*	*Moderate*	*12*	*R2*
	Lack of transparency	*Occasionally*	*Moderate*	*12*	*R2*
	Political orientation	*Occasionally*	*Moderate*	*12*	*R2*
Management risk	*Failure to provide documents and information on time*	*Occasionally*	*Moderate*	*12*	*R2*
	Poor site management and supervision	*Occasionally*	*Moderate*	*12*	*R2*
	Poor communication between involved parties	*Occasionally*	*Moderate*	*12*	*R2*

6.2.3 A Bayesian Belief Network Building Construction Project Modelling using Netica Software

After the relevant risk factors were assessed and classified, the interaction between them was analysed in a Bayesian belief network model. The Bayesian belief network was constructed by structural and parameter learning using the Netica version 5.0 which is a type of BBN decision software.

Determination of the relationship between the risk factors was done through subjective judgement of the researcher based on the review of literature on risk factors affecting building construction projects and also on the results from the data collected on risk factors in the Nigerian construction industry. With the help of the Netica software V5, the interactions of the risk factors were linked to determine their cause and effect relationships in building construction projects. Based on the results gathered from the survey, Netica helped to represent the perception of construction practitioners in order to determine the risk level of each risk identified using visual representations. The risks factors were analysed to determine how they resulted in cost overruns, quality assurance issues and time overruns on projects.

Figure 6.1 shows the graphical output of the BBN model to support risk management in building construction projects in Nigeria. The use of Netica helped to make the risk factors easy to show, the network of risk factors and the relationship between them in a graphical model. As seen from Figure 6.1, it becomes easy to trace risk factors and their cause and effect relationships. A typical example from the BBN model developed to support risk management in building construction projects in Nigeria is ‘rush design’. The cause and effects of rush design can easily be traced from the model as follows: rush design leads to incomplete and inaccurate estimates which then leads to poor communication between the involved parties, which directly causes quality problems and time overruns. Rush design is also shown to be influenced by awarding the design to unqualified designers.

Risk factors that directly affect building construction performance are referred to as proximal factors in a BBN model. The other risk factors that indirectly affect building construction project performance are called distal factors. In the BBN model shown in Figure 6.1, for building construction project performance, time overruns and quality problems were more significant risks than cost overruns in building construction projects in Nigeria. In the Nigerian context, proximal risk factors leading to quality problems were improper construction methods, poor communication between stakeholders on the project, and supply of defective materials in building construction projects. Proximal risk factors leading to time overruns were also identified to be quality problems, cost overruns, improper construction methods, poor communication between involved parties and delayed payments for contracts. Cost overruns were found to be linked directly to fluctuation of material prizes and unsuitable leadership style in building construction projects in Nigeria.

Figure 6.1 shows a BBN model for risk factors affecting building construction performance and the cause and effect relationship among risk factors. Risk factors that directly affect building construction performance are referred to as proximal factors in a

BBN model. The other risk factors that indirectly affect building construction project performance are called distal factors.

In the Nigerian context, quality problems were directly related with improper construction methods, poor communication between stakeholders on the project and supply of defective materials in building construction projects. Time overruns was directly linked with quality problems, cost overruns, improper construction methods, poor communication between involved parties and delayed payments for contracts. Cost overruns were found to be linked directly to fluctuation of material prizes and unsuitable leadership style in building construction projects in Nigeria.

NB: For the BBN model shown in Figure 6.1, all risk factors were identified from the literature on risk management in building construction projects. The most significant of the factors for the purposes of risk management in building construction projects in Nigeria, the data collection through questionnaires was used to reduce risk factors from the literature to the 27 shown in the BBN model. The linkages between the factors were done based on information from the literature review and subjective judgement.

In terms of applicability, the model is expected to be applicable to risk management in construction projects especially building construction projects within the developing country context where majority of the risks identified in the model are expected to be present.

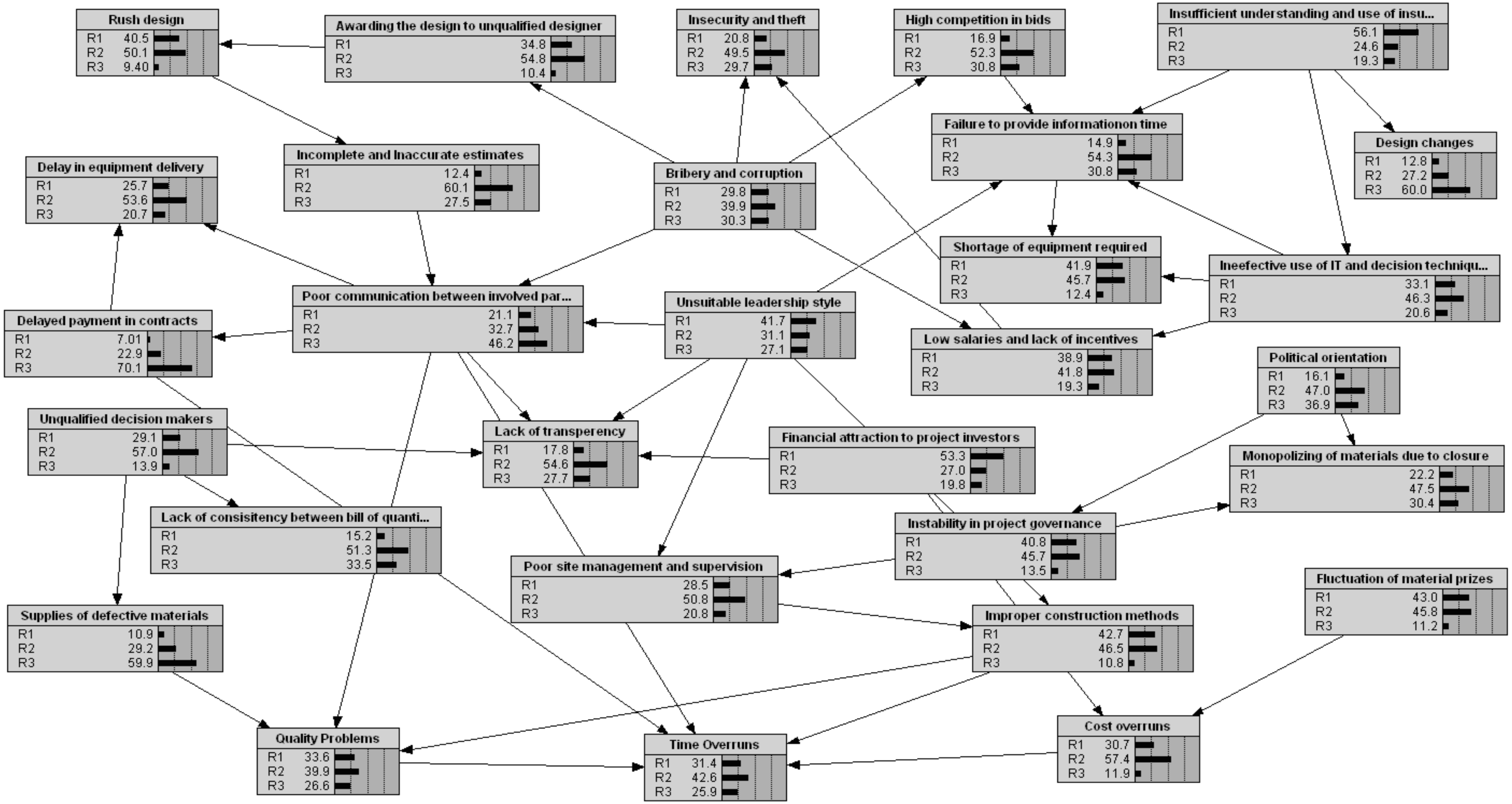


Figure 6.1: A Bayesian belief network model to support risk management of building construction projects in Nigeria

6.2.4 Risk Control Strategies in the Mitigating Concept

After a Bayesian belief network is constructed, a sensitivity analysis is carried out using the Netica software which measures the degree to which findings at any node can influence the beliefs at another node, giving the findings currently entered (Lee et al, 2009). The measures are in the form of mutual information or entropy reduction, or the expected reduction of real variance. Sensitivity is represented by entropy: larger entropy between nodes produces a bigger influence (Lee et al, 2009). This suggests that where the entropy values for risk factors on a node are high, then those factors have the highest influence on that particular project performance variable occurring.

Sensitivity analysis was conducted for the proximal risk factors identified in the BBN model shown in figure 6.1. Entropy reduction or mutual information values were calculated for sensitivity analysis of the 9 risk factors identified to directly affect project performance. Table 6.4 shows the results of the sensitivity analysis and entropy reduction data.

Table 6.4: Summary of the sensitivity analysis for building construction projects in Nigeria

Project performance	Risk factor	Entropy reduction
Quality problems	Improper construction methods	0.35924
	Poor communication between involved parties	0.41315
	Supplies of defective materials	0.32919
Time overruns	Quality problems	0.43558
	Cost overruns	0.32620
	Improper construction methods	0.35924
	Poor communication between involved parties	0.41315
	Delayed payment in contracts	0.25935
Cost overruns	Fluctuation of materials prizes	0.36223
	Unsuitable leadership style	0.43339

Results from Table 6.4 suggest that risk factors leading to quality problems in order of influence are: poor communication between involved parties; improper construction methods; and supplies of defective materials. For time overruns, the risk factors in order of influence are: quality problems; poor communication between parties; cost overruns; improper construction methods; and delayed payments in contracts. Cost overruns were influenced by unsuitable leadership styles followed by fluctuation of material prices.

Since the proximal risk factors affecting building construction project performances were all internal risks, risk reduction can be achieved through risk control efforts exerted by building project contractors.

6.3 Chapter Summary

A properly implemented risk management process will enhance the successful completion of engineering construction projects and thereby making the project more profitable. In a building construction project where cost, time and quality really matters, executing a project within the specified budget, time frame and optimal quality is critical, therefore, predicting the likelihood of risk factors plays a key role toward project success. This chapter presented a BBN model that support risk assessment for building construction projects. It summarised the research noting parts of the major findings. Since risk assessment is a critical procedure for decision-making and projecting success. This chapter on the basis of the qualitative assessment of the BBN presented the critical risk factors that affect building construction projects. The research results were obtained through the questionnaire survey conducted in Nigeria. A total of 27 risk factors were ascertained based on a comprehensive assessment of their magnitude of their impact and likelihood of occurrence. The risk acceptability matrix (RAM) was used to determine the most critical risk that affect building construction projects in Nigeria. On the basis of the quantitative aspect of the BBN, it developed a systematic and integrated approach for risk management in a Bayesian belief network model to analyse key risk factors affecting project performance, with a view to predict the worst and best case scenarios and thereby guide project planning. The BBN model application can also be applied to a variety of decision-making and sensitivity analysis in construction challenges. The Bayesian belief network is proposed for building construction risk assessment in this research because they allow inference based on observation and calculate conditional probabilities of risk factors. Bayesian belief network are more flexible to use more than other statistical methods and modelling tools. Having developed such a systematic and integrated BBN model, the research moves to validate the model from building construction practitioners' viewpoint. The next chapter presents the validation process.

CHAPTER SEVEN: VALIDATION OF THE BAYESIAN BELIEF MODEL TO SUPPORT RISK MANAGEMENT OF BUILDING CONSTRUCTION PROJECTS

7.0 Chapter Introduction

The previous chapter presented a risk assessment methodology based on the Bayesian belief network model for building construction projects in Nigeria (See section 6.2). However, the extent to which the Bayesian belief network model can be relied upon depends on the validation processes conducted in establishing its acceptability as a tool. The aim of the validation process is to determine whether the research findings and recommendations used for developing the model are sound and also, to establish whether these findings and recommendations are reliable. Validation is vital because it reveals the potential objectivity and reliability of the research. The next section presents a general discussion of the concept of validation then the method adopted for undertaking the validation exercise. Subsequently, the details involved in each of the validation procedures are discussed.

7.1 The Concept of Validation

Construction engineering and management research examines real-world means and methods as an effort to improve the effectiveness and efficiency of the construction industry (Lucko and Rojas, 2010). As reported in Lucko and Rojas (2010), in any scientific enquiry, it is essential that researchers use appropriate validation techniques to ensure the quality of their work in every step of its methodology, including data collection, analysis, and interpretation of results. Validation is a key part of the model development process which increases confidence in the use of the model and makes it more valuable (Kennedy, Xiang, Madey and Cosimano, 2005). As such, the purpose of validation is to ensure that each phase of the chosen research methodology rigorously adheres to the highest standards of quality (Lucko and Rojas, 2010). This level of quality in planning, executing, and evaluating research is measured as validity (Lucko and Rojas, 2010). According to Hair, Black, Babin and Andersoan (2010), validation is the process of assessing the degree to which a measure accurately represents what it purports or is required to measure. However, validation process is carried out not only to establish the validity of research findings but also the validity of the research design (Brewer, 2000). The process of validation can be broadly divided into two main areas:

establishing internal and external validity which has been successfully employed by many researchers (e.g. Proverbs, 1998; Xiao, 2002; Ahadzie, 2007; Ankrah, 2007; Egbu, 2007 and Ikpe, 2009).

Internal validity is related to the concept of causality and is preoccupied with the derivability of relations within data (Leedy and Ormrod, 2001). External validity is related to the concept of induction and focuses on the generalizability of results for prediction purposes (Leedy and Ormrod 2001).

Besides internal and external, other types of validity that are commonly referred to in literature include face validity, content validity, criterion validity, and construct validity (Lucko and Rojas, 2010). Face validity is a subjective judgment of non-statistical nature that seeks the opinion of non-researchers regarding the validity of a particular study (Leedy and Ormrod, 2001). Content validity is another non-statistical approach that focuses on determining if the content of a study fairly represents reality (Lucko and Rojas, 2010). Its primary concern is “the degree to which a measure covers the range of meanings included within the concept” (Babbie 1990). Criterion validity is defined as “the extent to which the results of an assessment instrument correlate with another, presumably related measure (Babbie 1990). Construct validity refers to whether operationalisations of theoretical constructs are appropriate (Lucko and Rojas, 2010). In other words, construct validity is concerned with ensuring that a research effort is measuring what it is supposed to measure according to its stated objectives (Leedy and Ormrod, 2001).

7.2 Bayesian Belief Network (BBN) Model Validation

The validation of a model is the process of confirming whether the proposed model is appropriate, especially in the light of the purposes of the investigation (Frees, 1996). Egbu (2007) describes the validation of a model as the process of assessing the ability of the model to do what it sets out to achieve. This process attempts to ensure that the model represents the characteristics of the general population and is not peculiar to the samples used in its estimation (Hair et al, 1998).

The extent to which the findings of the research can be trusted depends on the process of validation undertaken to confirm or unconfirm the research findings. The two major components of validation (internal and external) were used to validate the BBN model and are described in the later sections. The model was derived mainly from empirical data analysis of the quantitative research in this study.

7.2.1 External Validation of the BBN Model

This is the process of establishing the extent of generalisability of research findings in spite of variations in the settings, persons and research method adopted (Shadish et al, 2002; Fellows and Liu, 2008). According to Brinberg and McGrath (1985), external validation process is meant to promote confidence in research findings and it is a process that transforms findings to knowledge.

External validity was achieved in this research by allowing construction stakeholders to share their views on the BBN model in two case studies. The case studies was used to identify risk factors and validate the relationships between the risk factors and how they affect project performance (cost, time and quality) as presented in the BBN model. The feedback received is generally encouraging and suggests that the BBN model has the potential of being well received. The outcomes suggest that the BBN model useful in terms of managing risk factors that are associated with the building construction sector in Nigeria. The summaries of the case studies used and the data collection are provided in the following section of this chapter.

7.2.2 Design of Data collection Instrument(s) for Validation

The research used data from three main sources to validate the BBN model for risk identification and management on building construction projects.

7.2.2.1 Interviews

- Project team members involved with management of the case study projects were interviewed. These included project managers, project directors, quantity surveyors and site supervisors. Data collection focused on the identification of risks or risk factors on the project and the relationships between the factors identified on the projects. This also involved the views of the project participants on the accuracy of the BBN model (See appendix G and H for interview guide).

7.2.2.2 Documentary Analysis

- Documentary analysis focused on collecting data from project documents to capture project information and any other planning information prepared for the execution of the project. The information included project reports, payment certificates and contract documents and other project documentation issued during the execution of the projects.

7.2.2.3 Site Observations

- Project site observations were done to help observe project performance such as work in progress, the presence of defects, working conditions on the projects, health and safety related issues and any other information relevant to the case study.

7.2.3 Summary of Case Studies and Sources of Data

Data collection involved interviews with key players on the building construction projects as well as site visits and documentary analysis as shown in Tables 7.1 and 7.3. The interviews concentrated on risks that had been identified on the projects by the project management teams. The aim was to help identify how the various risk factors identified linked to each other and impacts they may have on the projects. There was also a focus on the risk factors that were peculiar only to the construction activities in Nigeria and what the causes of such risks may be.

The interviews concluded with the interviewees being provided with the BBN model from this research and a discussion on how the various risks presented on the model linked to or influenced each other. For this section of the interviews, the case projects (Table 7.0 and Table 7.2) as well as experiences from different projects in the past was used as the basis for providing information.

Case Study One: Construction of a 5 Bedroom Residential Building at Yenagoa, Bayelsa State of Nigeria

Table 7.0: Case Study One Summary

Project Features	**Details**	**Comments**
Type of project	Construction of a new residential building 5 bedroom villa	
Project Sum	55 Million Naira (about £180,000)	This is the cost of the project including all fittings and fixtures
Project Duration	35 weeks	Initial project duration as at the time of contract commencement
Type of Client	Developer (estate agent)	A housing provider who specializes in the construction of Luxury apartments in Southern Nigeria.

Type of construction technology	Mainly masonry construction	The construction involved mainly masonry construction
Progress as at time of Data Collection	28 weeks into the project	As at the time of visits, the project manager indicated that the project was running 20% behind the scheduled completion date.
Risk factors identified	Possible overrun of project Duration and Initial cost estimated	Due to the delay, there was the risk of the project not finishing on time. There was also the risk of increased project cost.
Location of Project	Diete Spiff Road, Ovum, Yenagoa, Bayelsa State	

Table 7.1: Sources of data for case study one

Source of Data	**Details**	**Comments**
Interviews	**5** people were interviewed from this project. The five people included from the contractor's side, the project manager for the construction firm, the site manager, and the contractor's quantity surveyor. The architect in charge of the design, and the quantity surveyor representing the client were also interviewed.	Due to the contract arrangements for this project, there was the need to talk to the architectural company for the client and the quantity surveyor employed by the client to manage things on their behalf. Interviews span between 20 to 35 minutes per person.
Site visits	Three site visits within a span of two weeks	The site visits were made to observe construction works and identify any risks as a result of work processes.
Documentary Analysis	Project Data files including contracts showing duration and cost information as well as parties to the contract	

Case Study Two: Construction of a Shopping Centre Complex at Port Harcourt, Rivers State of Nigeria

Table 7.2: Case Study two Summary

Project Features	**Details**	**Comments**
Type of project	Construction of a shopping centre	The project comprised the construction of a shopping centre with space for about 15 different shops
Project Sum	105 Million Naira (About £345,000)	This is the cost of the project and excludes most of the fittings as this will be provided by the shop owners
Project Duration	60 weeks	The project was scheduled to take 60 weeks to be completed close to the Christmas season
Type of Client	Developer	A commercial properties developer specializing in the provision of offices for commercial purposes and the building of shops to lease.
Type of construction technology	A mix of masonry and mechanical construction technologies	
Progress as at time of Data Collection	40 weeks into the project	Though the project still had about 20 weeks to completion based on the original program, the project was 10 weeks behind schedule
Risk factors identified	Possible overrun of project Duration and Initial cost estimated	Due to the delay, there was the risk of the project not finishing on time. There was also the risk of increased project cost.
Location of Project	Rumodani Road, Elelenwo, Port Harcourt, Rivers State	

Table 7.3: Sources of Data for case study two

Source of Data	**Details**	**Comments**
Interviews	**7** people were interviewed from this project. They include; 2 people from the developer in charge of managing the project for the client 3 people from the contractor and 2 people from the Civil engineering and architectural firm	Interviews span between 20 to 35 minutes per person.
Site visits	Three site visits within a span of two weeks	The site visits were made to observe works and identify any risks as a result of work processes.
Documentary Analysis	Project Data files including contracts showing duration and cost information as well as parties to the contract. It also showed the contractual roles to be played by the parties to the contract.	

7.3 Case Study One - Construction of Residential Building

The essence of the case studies was to help validate the findings from the questionnaire survey, the BBN model built for risk and their effects on quality, time and cost performance of construction projects. For validation purposes, a multiple case study approach was used and this involved two case studies with single units of analysis. This section presents the analysis of the results from the two case studies involving two private sector construction projects. Interview guides for the various participants or project team members were prepared which formed the basis for collecting data. Also a model for risk management that shows the interrelationships for the various risks was provided to the participants to determine the reality of the relationships and interconnections based on their experience in the construction industry. Summary of the case studies and a brief background of the cases are provided in the sections below.

7.3.1 Case Study Background

Case study one involved the construction of a residential apartment by a private developer in Yenagoa, Bayelsa State of Nigeria. The entire project was scheduled to be completed within 35 weeks and involved the construction of a new 5 bedroom building including all fittings and fixtures. The construction was on a green field site and the client was a private developer who specialises in providing plush residential accommodation for sale. The building was designed by an architectural firm who partnered with a structural engineering firm whereas the construction firm was put in charge of all construction works from start to the handover of the property. The initial project sum for this project was estimated to be fifty five million Naira (about £180,000). The project involved mainly masonry units. As at the time of data collection the project had gone on for 28 weeks. The project manager however indicated that considering the amount of work left for completion, the project needed at least 12 more weeks to complete. This suggested the project was about 5 weeks behind schedule based on the initial programme and the project was expected to overrun the initial cost due to the time overruns. The project had no specific person in charge of risk and the project manager for the contractor who had oversite responsibility of all activities on the project was in charge of ensuring the project progressed on time, within budget and to a high standard of quality. This made the project manager ultimately the risk manager on the project.

7.3.2 Sources of Data for Case Study One

For case study one, the main sources of data were interviews with project participants; analysis of project documentation such as tender documents as well as planning and other project information; and observations through site visits. Table 7.4 presents a summary of the sources of data.

Table 7.4: Profile of interviewees on project 1

No.	Interviewee	Role on Project	Educational Background	Years of Experience
1	Contactor's Project Manager	Overseeing day to day running of project	Masters in Project Management	10 Years
2	Quantity surveyor	Responsible for the cost estimates of the project	BSc Quantity Surveying	7 years
3	Site Manager	Establishes and manages the site work force	HND Civil Engineering	6 years
4	Architect	Responsible for the design of the building	BSc Architecture	18 Years
5	Client's Quantity Surveyor	Feasibility studies of the client request as well as providing clients value for money	HND Quantity Surveying	14 years

The analysis and the results from this case study are presented under the following: the main sources of risks; common risk factors; risk factors specific to the Nigerian construction sector; the results of such risks should they occur; and the relationship between the risk factors presented in the model.

7.3.3 The Main Sources of Building Construction Risk

Based on the interviews conducted, the documents analysed and the visits made to the site, a number of factors were identified as the main sources of risks on the project. These were client activities (including cash flow); contractors' internal activities; external influences (sources outside the client and the contractor). These risks were found to have a likely influence on quality; time; and the cost of finishing the project and are discussed below.

7.3.3.1 Risk Factors as a Result of Client activities

From the interviews with the members of the building project team (especially from the contractor's side), a common notion was that the activities of the client have a major role to play in introducing risks to the project. From their perspective, the client has the overall say on the project including the financial aspects of the project and as such the activities of the client especially on this project led to a chain of risk factors. According to them, one main area in which the activities of the client affected risk was the area of cash flow. As the project manager and the quantity surveyor for the contractor suggested, when the client delays in the payment for work done, this affects the cash flow of the contractor and ultimately leads to other risks such as delay in the progress of the work. In his own words, the project manager puts things this way: *'according to our program for this contract, the client was meant to pay for work done at the end of the 16th week. The client however delayed this payment until the end of the 19th week. For this reason, as a contractor we did not have enough money for the purchase of materials and even for the payment of workers which occur on daily basis. This lack of funds meant there were some days that we had to reduce the number of people who could work on site.'*

The project manager further went on to explain that, the influence of the client on risks is not just delay in cash or cash flow issues. There were many instances where the architect had brought about some changes in the design of the building (upon the insistence of the client) and this made the project to halt until certain changes were made. As they explained, there were times when work done had to be broken down to allow changes to be effected in the project. Analysis of the interviews with the architect and the quantity surveyor representing the client also suggested the client had a major influence mainly through request for changes and the delay of payment (in some few instances). In commenting on the influence of changes in design in introducing risks to the project, the quantity surveyor for the client suggested that whenever there was a change in the design of the building especially in instances where already built sections have to be broken down to make way for modifications, this introduced an increase in the cost of the project making design changes a big risk to the cost of the project.

7.3.3.2 Risk Factors as a Result of Contractor's Internal Activities

On the risks to the project that are attributable to the contractor's own activities, a number of risk factors were identified on the project. These include: insecurity and theft at the project sites; bribery and corruption involving the contractor or contractor's team; ineffective use of technology; improper construction methods; poor leadership on projects; little motivation of project staff; poor communication and poor site management. According to the interviewees on the project, though some of the risks on projects can be attributed to external influences or sources, in most cases the contractor plays a major role. There were comments from the contractor's project manager and quantity surveyor which suggested that some of the risks on the project were as a result of failure on their part as a contractor to put things in place. According to the project manager, *"…there are some times that the risks that can cause increased cost* and delay *in delivery of projects are our faults. Like on this project, we realised there was usually some bags of cement missing from the site. After some time we realised that the store keepers on site have not been doing their work well and as a result they allow other members on site to steal some material especially cement out of the site."* He suggested that such problems are as a result of improper management of the site and lack of proper security which leads to theft at the project site. From the interview with the quantity surveyor, such issues including the use of wrong construction methods sometimes lead to misuse of materials which come with cost implications and in some instances delays in the progress of works.

The quantity surveyor also commented on lack of motivation that occurs sometimes on the project site as some of the causes of delay and increased cost of projects. In his words, "*…One main area is the motivation of site teams. Once they are not well motivated, be it as a result of payment problems or some problems with the foreman or other managers on site, they do not give their best and that causes delays in so many ways. So the site teams, once they are well taken care of and motivated to work harder, you are sure they will deliver and do their work well."* From these comments and others, it was evident that the contractor and the activities of the contractor pose risk factors to the project. The architect on the project suggested some quality issues are as a result of the contractor either using wrong construction methods or buying defective or sub-standard materials for the construction process.

7.3.3.3 Risks Factors as a Result of External Influences on the Building Project

From the interviews, it was gathered that some risk factors are neither the cause of the contractor nor the client's activities but are external. These factors mainly had to do with macro-economic activities in Nigeria as well as other social activities that the contractor has no control over. The project manager suggested that an issue like the general lack of transparency in the Nigerian construction industry is a major cause of risks. According to him, the issue of lack of transparency leads to *bribery and corruption activities which* means you have to *'settle'* some people even before you get a project. According to him, due to these activities that go on right from the award of the contract stage, there are many instances where genuine complains cannot be made due to previous undisclosed dealings. Another external problem was the contractor buying defective materials (without his knowledge) and this having a negative effect on the quality of construction (projects). According to the client's quantity surveyor: *"some of these issues are not the fault of the contractor, I think it is a general problem in the country where you can buy materials only to later discover that they are fake or not of good quality* (defective materials). According to him, these are issues that must be tackled at a national level. Of all these a number one external factor was the issue of price fluctuations. Almost all interviewees on the project agreed that the high inflation rate in the country is a major external factor that affects the management of projects. In the words of the contractor's quantity surveyor: "*an inflation and price increase is the number one issue if you ask me. Prices in Nigeria increase all the time. As a result, if you do not buy your materials on time or buy to keep for your projects, by the time you get mid-way, prices have increased so much and you will be losing."* This increase in price was known to affect the cost of project delivery and contractors are in most cases not in the position to buy so many materials ahead of time due to financial difficulties. The interviewees from the client's side however suggested that the contractor can well manage some of these risks if they properly plan for their projects. For this reason lack of proper planning on the side of the contractor was reemphasized as a major cause of risks on the project.

7.3.4 Risk Factors Peculiar to the Nigerian Construction Sector

An attempt was made to identify the risk factors that were deemed peculiar to the Nigerian construction industry but may not be common risk factors in other countries (especially developed countries). Interviewees from this project suggested that though they may not have worked in other countries, they believe certain risks like intentionally hoarding goods to increase prices may not be a common problem in other countries. They also suggested that the lack of transparency and the use of unskilled people as professionals either by the client or even by the contractor may be something that will not be very common in other countries, especially in developed countries. From the interviews, it was evident that the client's refusal to pay for work done on time which is a very common issue in the Nigerian construction sector irrespective of the kind of client (private, government etc.) must be either a regional or Nigerian problem as they don't expect that to happen in certain advanced countries. Also the lack of coordination between project teams at some points in the project (each member trying to show their importance over other project team members) leads to poor communication which in so many ways affects project delivery time.

7.3.5 Interrelationships between the Risk Factors Presented in the BBN Model

When presented with the BBN model to determine the relationships between the factors presented in the model based on the current project or experiences from other projects, it was evident that not all the risk factors presented in the model were present on the current project. The interrelationships were validated taking the three main project delivery outcomes that can be affected by the risks should they occur: time overruns, cost overruns and quality problems. Each interviewee was taken through the model to determine which relationships they felt were either not correctly linked or omitted. The results are discussed below.

7.3.5.1 Time Management to Minimise Overruns

As presented in the BBN model, the main factors leading to time overruns on projects were: quality problems; improper construction methods; delayed payments; and poor communication. From the interviews with the project participants, the general conclusions is that the main causes or sources of time overruns on projects were delayed payments, quality problems leading to rework, poor management and supervision of workers on site and the use of obsolete construction methods. From analysis of the discussion with the interviewees, it was deduced that improper construction methods, quality problems and delayed payments were the main direct causes of time overruns. According to the project manager on the project, *"everything comes down to cost and payments in the construction industry. The number one thing that can affect progress of work leading to time overruns is delayed payment"*. This point was re-echoed by other interviewees. They suggested that once payment of the contractor is delayed by the client, it causes delay in the payment of workers which can affect productivity and attendance to work, can affect the ability of the contractor to purchase materials which also leads to slow progress. On the issue of quality problems leading to time overruns, it was ascertained that quality issues are normally either due to poor quality of materials and construction methods which comes from quality and level of supervision. It was gathered that when such quality problems lead to a break in the flow of work or the need to rework certain aspects of the project, that is when they affect time overruns. Improper construction methods were identified to be the second most influential factor on time overruns. Issues of this nature arise out of the lack of competence on the side of operatives or poor supervision of workers. In such instances, people on site can easily make mistakes which need to be corrected or may be slow in the delivery of work. Delay in the delivery of materials or equipment to site (which was identified as common issues in the construction sector) was also identified as having an influence on time overruns. As the quantity surveyor for the client on the project mentioned, *"In this industry, you work with people, materials and plants. In most cases these plants are not yours and you need to hire. Unless you plan well ahead, delays in you getting plants can affect your program leading to time overruns".* The delay in materials and equipment delivery was also attributed in one way or the other to the inability of the contractor to pay for materials on time.

7.3.5.2 Quality Assurance to Minimise Underperformance

The second project delivery outcome or target which in most cases gets affected by risks is quality assurance. According to the client's quantity surveyor on this project, quality is one major area they seek to ensure is achieved on all projects and yet one common area where majority of projects suffers. Risk factors affecting quality assurance or leading to quality related problems were identified as supply of defective materials, improper supervision, the use of improper construction methods, poor communication between project participants, rush designs, corruption and lack of transparency. From the contractor's representatives on this project, quality related issues mainly come about when materials supplied are found to be defective which results from lack of transparency in the bidding process or as a means to control cost. It was also suggested that one main area that affects quality assurance is the issue of lack of proper communication or lack of proper preplanning which may be the fault of the designer or the client's representative. This the project manager for the contractor explained as follows: '*for quality it is very important that we ensure the quality of the projects is high and meets the demands of the client. Areas that can affect quality are mainly having the wrong or low quality materials which happens normally when people without adequate knowledge make the decisions or there are some rush designs which have to be later changed.´* To this the quantity surveyor of the contractor added that "*sometimes when the bills of quantities have wrong values which have been used for purchases, the problem of quality come to bear when the site team sometimes have to make up for some shortages*".

Quality issues are also known to arise out of poor communication especially between the contractor and client's representatives or even between the contractor and his site team. These factors contribute to poor quality of the work in the end.

7.3.5.3 Cost Management to Minimise Overruns

From the analysis of the data on the causes of cost overruns, it was identified that cost overruns was the most important aspect of project delivery that the site team (of the contractor) paid attention to. The most influential factor that led to cost overruns was time overruns. Other factors included constant increases in the price of materials (inflation), high level of theft on project sites due to lack of proper security on site, and misuse of materials. According to the contractor's project manager, delays' leading to cost overruns was as a result of the nature of the industry. He suggested *"because in this industry people are not based on monthly work like many other industry here in Nigeria, you pay people based on the a daily work basis, so if you delay, means you will have to pay for more days and that leads to cost overruns. Also if it is a kind of contract where the client is strict, with every delay, you have to pay LADs and that increases your cost (as a contractor)."* This was agreed by other participants on the project including the client's quantity surveyor. Inflation as a cause of cost overruns on projects was also a common factor agreed by all participants of the research. According to the Client's quantity surveyor, *inflation is the number one influence on projects due to the rampant increases in the prices of goods here in Nigeria. These increases mean the prices of materials for construction projects will increase leading to a swelling of the project budget."* The extent to which increases in the price of materials affect the cost of projects is also as a result of lack of finances to buy materials in bulk or to stock up enough materials for the duration of the projects. This means any time there are price increases, the project directly gets affected. Misuse of materials was the other risk factor that leads to cost overruns on projects. As gathered from the project, the cost of materials made up a huge portion of the total project cost and as such misuse of materials means the need to buy more materials to make up and this increases project budget. This was identified as a major issue for the contractor who in most cases bore the burden of such increases. The misuse of materials had the same effect as high levels of theft which also leads to the need to buy more materials to be able to make up. The contractor's quantity surveyor explained this as follows: "*theft can be compared to the misuse of materials, as people steal the materials, especially cement and other materials that can be easily taken off site, as a contractor you need to buy more materials to ensure you can complete the work or work section and this means increased cost. When this is allowed to go on for a longer time, it swells the budget, just like misuse of materials.*" These two factors lead to increased purchases and ultimately cost overruns on projects.

7.4 Case Study Two – Construction of a Shopping Centre

7.4.1 Case Study Background

Case study two involved the construction of a shopping centre by a private developer who specialised in constructing commercial facilities in southern Nigeria. The total duration allocated this project was 60 weeks with a total project sum of 105 Million Naira which includes the construction of the main structures of the shopping centre without fittings for the 15 different departmental shops. Due to the nature of the project, an architectural firm was in charge of the design of the project whereas a civil engineering firm did the structural works. As at the time of data collection, the project duration was 10 weeks behind schedule and was projected to be completed with a 10% increase in the initial project cost. This project had the contractor's quantity surveyor acting as risk manager to ensure risks inherent in the project were well managed during the execution of the project.

7.4.2 Source of Data for Case Study Two

For the purposes of this case study, data was collected through two main sources: interviews with the site team; two site visits to observe activities on site; and documentary analysis. A summary of the sources of data is presented in the Table 7.5.

Table 7.5: Profile of interviewees on project 2

No.	Interviewee	Role on Project	Educational Background	Years of Experience
1	Contactor's Project Manager	Overseeing day to day running of project	Masters in Project Management	10 Years
2	Quantity surveyor	Contractor personnel in charge of cost administration	BSc in Quantity surveying	14 years
3	Site Manager	Establishes and manages the site work force	HND in Building Construction	9 years
4	Client's quantity surveyor	Feasibility studies of the client request as well as providing clients value for money	BSc in Quantity Surveying	4 Years
5	Client's project manager	Responsible for ensuring that the project and project team deliver the expected outcome and benefits to the client.	MSc in Project Management	6
6	Architect	Responsible for the building design	HND Architecture	15
7	Civil engineer	Responsible for the technical and feasibility studies of the project	BSc Civil Engineering	3 years

Results from the analysis of this case study are presented below and covers five major themes: common risk factors on the projects; risk factors specific to the Nigerian construction industry; and the relationships between risk factors as presented in the model.

7.4.3 The Main Sources of Building Construction Risk

For this case study, the main sources of risk on the project were identified to be contractor's internal activities, client's activities, external influences such as culture of the local people, government activities, and the attitudes towards safety issues in the construction industry. These factors affect at least one of the three main attributes of time, cost and quality. The themes are discussed below.

7.4.3.1 Risk Factors as a Result of Client's activities

Form the data collected, it was evident that, though the risks generally arise during the construction process, the activities of the client before and during the construction phase of projects is largely responsible for the risks that may occur on the project. These risks as explained by the interviewees range from decisions at the design stage which include the type and quality of professionals used during the design stage, the time allowed for the design team to get things right from the beginning, future changes to the drawings (designs) that occur after the construction works have started among many other things. Other activities of the client as captured on the project were ability to meet payment obligations and on time, ensuring transparency in award of contracts, the use of qualified personnel to monitor and manage the project for the benefit of the client. As captured from this building project, these activities of the client in most cases pose risk to cost, time and quality of the building project based on the kind of risk posed by the client. As explained by the client's quantity surveyor on the project, "*the client has a major impact on the risks that are likely to arise on the project and these can affect any of the performance criteria; time, quality and cost. Let us say if the client is not able to decide on the type or designed early enough but wants the project to progress, it will definitely lead to some issues as changes may have to be made when construction had already begun."* He continued, …*when this happens, it can affect the project duration as time may have to be spent on breaking down what has been constructed and rebuilding. This will also affect the quality of the project to some extent and most importantly it will affect the cost of the project as it will mean doing double work.*

According to the architect's representative on the project, "*sometimes when the client does not allow enough time on their project, especially like this project which we need to make ready for the Christmas season, there is that tendency to make some errors which sometimes can be costly. These errors can sometimes be costlier and more time consuming than the initial delay that could have occurred.* He also suggested that rush designs which are normally caused by the client not giving enough time on the project leads to a lot of negative consequences which cover cost, time and quality.

Aside the design activity, cash flow is one of the major problems affecting the delay and quality of the project. Being an industry where cost matters a lot, payment of contractors on time affect so many factors which may even lead to or prevent project from finishing on time and within time. Aside time, late payment leads to quality related issues as the contractor may resort to the use of cheaper materials which are of low quality as gathered on this project.

7.4.3.2 Risk Factors as a Result of Contractor's internal activities

From case study two, the contractor's activities known to introduce risks to the project were captured as wrong planning and management techniques, ineffective use of technology, use of outmoded construction techniques, lack of motivation, poor site management, poor communication, unsuitable leadership styles and instability in management on site. As gathered from the data collected, these sources of risks arise from the actions or inactions on the side of the contractor and have an influence on quality, cost and time performance of projects. On this project, a common source of risk was the planning activities of the contractor. As explained by the client's quantity surveyor, part of the delays on the project could be attributed to the contractor not planning early enough for the delivery of materials on site. In his words, "*on this project, let's say five weeks ago, we were meant to start placing concrete to the first floor slabs but this could not be done as the contractor had run short of cement. Because of this unavailability of cement which is caused by the contractor not planning ahead of time, certain portions of the project had to be suspended until there is cement.* He further explained that when such things happen, not only does it affect the duration of the project, but has an influence on the quality of the project (ultimately).

During an interview with the contractor's quantity surveyor on the project, he suggested that the issue of delay in delivery of materials was as a result of the contractor's inability to procure enough materials in advance. This he explained was mainly related to finance issues faced by the contractor. When questioned what the financing situation is for the company, he explained as follows: "*the issue of financing of projects is a serious matter, as a contractor, it is very difficult to be able to obtain loan from the banks (and this is mainly due to our size and our assets), for this reason, it is very difficult to always have enough funds to always procure enough materials in advance. …On projects such as this one, (*he continued), *the absence of advance mobilization also makes the problem worse as the contractor always has to fund for the project until the payment is due.* With this, the general notion was that, the lack of funds on the side of the contractor (either delay payment or lack of funds to execute projects in advance) was in many ways the cause of the problems. This was confirmed though interviews with the other members of the project who suggested that lack of mobilization to start projects coupled with the inability to secure loans from banks makes the financial

situation of the contractor a very poor one. This in turn affects issues such as delays in materials delivery which leads to delays in the execution of projects.
The issue of financial difficulties was also found to be linked to the issue of bribery and corruption which was gathered to be a major factor in the construction industry in Nigeria. According to the interviewees, this makes people want to do things in inappropriate ways.

The project manager on the project cited certain risks on the project as the type of construction technologies used which makes work slow on site and leads to delay in delivery which also affects the cost of doing things and the quality of at the end. On this project, a common issue of this was the use of timber formworks which according to the site manager take longer to construct compared to metal formworks which was the current practice in the industry. According to him, "*there are certain simple technologies that can be used to speed up work, but most of the times these are not employed due to the type of leadership sometimes used on their projects.*" As gathered from the interview with him, the general culture of certain members put in charge of site teams make it difficult to adopt new technologies or practices poses some risks to projects.

From the site visits, it was evident that health and safety of workers was not given the utmost consideration and this served as a source of risk to the project. The type of scaffolding used for working on higher levels for example did not have enough protection which posed a health and safety risk to the operatives or labourers on the site. Another issue captured was the type of Personal Protective Equipment (PPE) worn by the site team. During the site visits it was very common to find people working without the correct PPE such as helmets. This suggested that health and safety had not been given the level of attention it required. When the project Manager was questioned about the effect of such risks on the project, he suggested that wearing PPE, though important, was not a prime area as many workers on site preferred working without them. He suggested that though health and safety issues do result in accidents sometimes which can lead to cost concerns and quality issues, this was not an area usually concerned by contractors. It was evident that health and safety issues had varied implications on risk on the project and had to be taken serious by the client.

Another source of risks as captured on the projects was the issue of leadership. In an interview with the person in charge of risk management on the project, he suggested that the leadership style adopted on the site affect issues such as time, quality and cost on the project. According to him, having an efficient management team on site ensured that workers adhere to standards of work set by the contractor. When asked how this affects cost, time and quality he suggested "*when you have bad leadership on a project, people can do things anyhow they want and this can affect quality of the finished project, not only that, you are bound to have mistakes, as people may do things wrongly which have to be corrected either by breaking the already done work and redoing the work which leads to increased costs and delay in the project.*" Leadership instability on projects was captured as a major source of risks as it has the tendency to affect all three project measures of time, cost and quality.

7.4.3.3Risk Factors as a Result of External Influences on the Building Project

External factors leading to risks on this building project were captured to be government activities, general culture and attitudes to work in Nigeria, the supply of materials and inflation, the nature of the construction industry and the allocation of roles, the activities of sub-contractors, and the high competition in bids. These factors are discussed below. On this project, external factors were captured to have been major sources of risks as they were said to have affected time and price to a large extent. Due to the nature of this project, the client had sub-contracted portions of the work such as mechanical fittings and floor finishes to specialist sub-contractors. Also, plumbing works had been sub-contracted. According to the risk manager for the contractor on this project, the activities of these sub-contractors pose external risk factors as they are not directly the responsibility of the contractor. Delays in their activities can cause delays to the project and the main contractor as work programs have to be modified to accommodate activities of sub-contractors. Aside the activities of sub-contractors, suppliers also have a big influence on risks as identified during this case study. As explained by the risk manager on the project, suppliers can pose a very high risk when they fail to deliver materials on time. The failure of suppliers to deliver key materials on time has varied implications on project duration and on cost ultimately. Another area in by which suppliers or sub-contractors pose a risk to the project was through the supply of defective or low quality materials.

This the quantity surveyor for the client explained the risk posed by suppliers of defective materials as follows: "*The problem with these suppliers is, sometimes they can bring you materials, let us say reinforcements, they know the bars have issues, probably the sizes are not up to the required sizes or strength and yet they will supply that to you. You may want to argue or reject it and that will mean you have to make new arrangements that will cause a delay in project time and all that. If you decide to try the next supplier, there is a high probability that they will supply you with similar defectives materials or they will charge you very high to provide the correct materials. When such materials get to your site, straight away you know you may have problems with quality. If client's team on site happen to notice that, then you are probably looking at cost as well if you are made to break and redo which will also lead to delays due to the extra work done.*

Other external factors were inflation rates which affected the prices of goods leading to an increase in the cost of finishing the project. As gathered from the research, prices in Nigeria are unstable and this is not something the contractor has control over. Inflation aside leading to the increase in prices of materials has other negative impacts on projects and this according to the quantity surveyor for the client adds delay to their projects in some instances. He explained this as follows: "*Sometimes when prices of materials begin to increase or people realise the prices of materials are going to increase, they intentionally hoard what they have in order to make more profits when prices have increased. In such a situation, we may not have materials available and that can lead to delay on our projects."* He continued to explain why things go that way, "… as I was saying, this is all part of the corruption we talk about in this country. People do these things so you have to spend more and then that affects your cash flow and or your time too. When asked whether or not there are price adjustments in their contracts to cover for this, the Project manager explained that generally the type of contracts they work does not include such options as adjustments for inflation and this brings extra cost to the contractor. He explained this as follows "*Normally, the type of contract you will sign as a contractor does not even allow for such adjustments. So right from the word go you know you are in for some trouble of a kind should prices increase rapidly. I don't know if it is same for the very big contractors, but you know as small contractors we don't really have a say and we have to suffer some of these issues.*

Interviews with other members of the project team (from both the client and the contractor's side) also suggested this was a common practice and sometimes lead to price increases as well as quality issues. As gathered, contractors in seeking to win projects at any cost, due to the high level of competition do not necessarily consider some of these issues but have to deal with them as the project progresses. It was also gathered that the level of competition leads contractors into finding ways and means to win contracts including unfair means. The quantity surveyor for the client put it this way: "*there is high level of competition in the country for projects and because of this, people* (contractors), *will do things anyhow to win. This includes either bidding as low as they can which leads to a reduction in their margin or findings ways of swinging the bids in their favour by 'arranging' with the consultants or even other contractors".* When asked what he meant by arranging, he explained that the was a process where a single contractor will buy many copies of the tender documents and submit them in such a way that he will win the contract or paying off the consultants in charge of the bidding process to win contracts. These corrupt practices he explained, has an influence on many other factors and ultimately leads to increased cost and low quality of projects.

7.4.4 Risk Factors Peculiar to the Nigerian Construction Sector

As part of this case study, the research sought to capture risks that may be peculiar to the construction industry in Nigeria (but are not likely to be found in other countries, especially, developed countries). Through this process, it was found that the issue of health and safety as a source of risk to building projects was very common though contractors did not see this as a major influence. In most cases, they just have not been considering it but it still affects projects in many ways. As indicated by the project manager "*I think health and safety is a major issue though we do not always consider that as part of the risk factors to our projects. People will normally not wear the overalls (*This he was referring to personal protective equipment - PPE), *or the contractor may not even have it. What we do have is the reflective vests which will be common to find on the site but boots and googles, we most of the times expect people to have their own.* This common practice was seen as a source of risk which could lead to high levels of safety issues and subsequently increased in costs and delay in progress. Another common factor that affects both quality and cost is the design and construction of temporary works and supports. As explained by the project risk manager, *temporary works like scaffolds are the main areas that can lead to such health and safety risks, but this has a lot more to do with the workers on site. Sometimes you come across people* *who believe their experience makes them free from falling or any such risks and will not easily want to be bothered with safety issues. Wearing of nose masks when working in dusty environment which is common in the industry is something many people will not bother themselves with.* It was identified that this actually does have an influence on the projects as sometimes key personnel may fall sick and this puts into question the quality of the projects some times.

Still in the area of health and safety, it was identified from the site visits that the conditions under which the site teams work sometimes pose severe health and safety risks which have effects on other aspects of the projects such as quality and cost. Aside the issue of not wearing safety gears, natural factors like rain and excess heat from the sun affect the building project delivery in many ways. It was gathered from the interviews that periods of torrential rainfall during the rainy season especially can have high effects such as site teams wanting to quickly finish their works for the day and as such leading to some shoddy work sometimes that affect quality. This was attributed to the lack of proper meteorological information on especially rains. The project teams suggested that there are not also accurate forecasts to be worked with or even in instances where they are around, the contractors may "*not even bother to look for it or at it" (project risk manager).* This was found to be as a result of the general culture of the people in the construction industry in Nigeria who would not normally worry themselves with such issues. The project teams would work and when there is incidents of rains, either work in it depending on the intensity or try their best to quickly finish the work under execution.

Financing arrangements for projects was also seen to be a major problem which could affect projects. The lack of advanced mobilization which is a common practice and inability to secure loans make financial matters very common in the industry. Apart from the inability to secure funds, there are instances where the client may delay payment even after the stage for payment is reached and this affect the cash flow of the contractors leading to them findings ways and means to get the project running by any means. Non-performance on the side of the client is a common issue in the Nigerian construction industry. Corruption is also another area that is very common in the Nigerian construction industry. Due to the levels of corruption that may even occur to win construction projects; there is also the tendency for the consulting teams to engage in further corruption. This the risk manager on the project explained is because the consultants know they helped you win the contract and sometimes makes it difficult for you to take them on when issues arise for fear of not winning further contracts.

7.4.5 Interrelationships Between the Risk Factors Presented in the BBN Model.

To determine how realistic or accurate the risk factors presented in the BBN model are, the teams involved on this project were given the BBN model to have a general read through to identify areas they could agree with as well as areas they would not agree with or felt were missing in the BBN model. The results are presented in three themes; time overruns, cost overruns, and quality problems as discussed below.

7.4.5.1Time Management to Minimise Overruns

Just as presented in the model, delayed payments was agreed to be one of the main areas that lead to time overruns on projects. This is because delayed payments means delayed progress of work due to lack of funds to secure materials. Delayed payments was also understood to be as a result of the client either failing to meet their obligations on time or the consultants not communicating properly or on time with site teams or clients. According to the contractor's personnel involved in the project, sometimes the client may be ready but the consultants may not communicate on time that work has been done to a level where the stage payment needs to be done. Another risk factor that delay payment caused aside from delay in equipment delivery was the lack of funds to procure materials which will also ultimately lead to a delay in project execution. As explained by the project manager, "*contractors normally will not have free money lying around, so if payments are delayed, there is the tendency that we cannot procure materials on time especially when shortages are anticipated, and this also means we cannot pay the workers (who are normally paid on daily basis or weekly basis) and as such no work on site. It was also identified that the delayed payment is sometimes linked to the bribery and corruption that involves the contractor and the consultants which leads to lack of transparency in the industry.* It was also confirmed (just as identified on the project), that cost overruns and quality assurance problems will ultimately have an influence on time overruns or late completion of projects.

Another area that was also identified to affect time overruns was the issue of poor management remunerations and lack of incentives which lead to low motivation of site staff. As explained by the risk manager on the project, when there is little motivation, productivity will reduce and that can affect the time used in finishing a project. Work that motivated site staff can finish in a day can take two or three days to finish when site teams are not motivated and this according to him can ultimately though to a minimal extent affect completion times on project. Shortage of equipment required (which results of failure to communicate information on time) and ineffective use of ICT, were also identified to affect the completion time on projects through the use of improper construction methods.

7.4.5.2 Quality Assurance to Minimise Underperformance

When discussing quality related issues, the consultants for the clients suggested that quality is one major area which is affected by many factors and as such gets more attention. From the BBN model, suppliers of defective materials, improper construction methods and poor communication between involved parties were stated as the main influences on quality. Discussion on this with the site team however suggested that, though these stand true, a key area affecting quality is the area of bribery and corruption. As explained by the client's consultant, *it is when there are issues with bribery and corruption that people tend to play down on quality issues*. This is because there are instances where people know they have an '*arrangement'* with the consultants or teams involved and as such quality can be compromised to ensure more money is made from the project. Rush designs leading to incomplete and inaccurate estimates and poor communication of this between the teams involved, just as captured in the model were agreed to be correctly placed. All these issues were however also traced to the activities of the client such as not allowing time for projects to be fully developed or rushing to get projects started and completed.

Another area that has an effect on quality through poor supervision and site management practices was design changes. This was agreed to affect quality especially in instances where the changes occur late and there is not enough time to ensure things are done right or the level of supervision is poor. This also leads to the issue of unqualified decision makers directly affecting quality on projects. Just as captured in the model, unsuitable leadership style which influences or results in improper construction methods also leads to quality problems. Just time overruns, lack of motivation due to the absence of incentives or low salaries can also lead to quality issues as workers may not be motivated to put in their best. Shortage of equipment required and ineffective use of IT were also identified to result in improper construction methods which ultimately affect the quality of works done.

7.4.5.3 Cost Management to Minimise Overruns

Cost overruns are considered to be very important to both the contractor and the client as they have high influences on the profitability of contractors and also on the funds of clients. From the model presented, fluctuation in prices and financial attachments to project investors were presented as direct influences on cost overruns. Interviews with the site team on the project however suggested that time is money in the construction industry and as such time overruns has a very high influence on cost overruns. This was identified to be especially so for projects where Liquidated and Ascertained Damages (LADs) may apply such time a delay on the part of the contractor to complete the project on time (either adjusted time or initial project time) will lead to the contractor losing money. The issue of quality problems was also identified to be one of the main causes of cost overruns. This as explained by the risk manager on the project, can come in the form of reworks due to poor quality of work. As he explained, "*when the level of quality for let's say a section of the work is found to be poor and the consultants wants you to redo, definitely your costs will increase* (though this may not be cost to the client, it becomes a cost to the contractor).

Improper site management and supervision was also identified to have an influence on cost as this may normally lead to material wastage on site or the use of improper construction methods. It was identified that wastage is very high in the construction industry in Nigeria (material wastage for that matter) and this affects cost of executing the project. Material wastage means more materials have to be procured or brought to the site to complete work and that brings an extra cost burden to the contractor.
Though there were no issues of theft of material son this site, theft and insecurity was another area identified to have an influence on cost as it requires the procurement of more materials to replace stolen ones.

7.5 Cross Case Analyses

This section analyses the two case studies to determine the similarities and differences between the two cases on risk factors on their projects. The cross case analysis also looks at the similarities and differences between the views of the research participants on the 'model' presented for validation.

7.5.1 The Main Sources of Building Construction Risk

From the two case studies, the main sources of risks can be grouped into contractor's activities, client activities, and external sources. The risk factors under these sources however differ between the two companies. The similarities and differences between the main sources of risks are discussed below.

7.5.1.1 Risk Factors as a Result of Client activities

On both projects, client activities were identified as a major source of risk. The effects of these on both projects were however different and the extent of the effects of activities on the projects differ. On both projects, cash flow issues were the main risk factor from the client's activities in the form of delayed payments. The results of delayed payments on project 1 were delay in the time needed to complete the project due to unavailability of funds to buy some required resources. On project 2 however, delayed payments did not just affect project time, but quality as well. Other risk factors from the client on project 2 included little time allocation for project which means project started without full set of drawings, leading to changes in design which means redo of certain parts of the work this affected cost, time and quality on project 2. On project 1 however, though there was enough time to have the design done, the client still made changes during the construction phase and that led to some risks such as cost increment and delay in project duration.

7.5.1.2 Risk Factors as a Result of Contractor's activities

On both projects, the activities of the contractor led to a number of risks that led to time, quality and cost issues. On project 1, sources of risks from the client activities included insecurity and theft on project sites, bribery and corruption, ineffective use of technology, improper construction methods, poor leadership, poor, site management, lack of motivation of staff and poor communication between project leaders. These led to increase cost and delays. Project two however had more sources of risk as a result of the client's activities. These included: wrong planning and management techniques, lack of motivation of project staff, poor site management, poor communication, unsuitable leadership styles and instability in management on site. The risk factors on project 2 resulted in project delays, cost issues and quality issues. Leadership issues on project 2 led to people making mistakes or not being very productive and this led to delays and quality issues as well as cost issues. On project 2, there were health and safety issues which resulted in accidents that affected quality, cost and duration of projects. Health and safety issues such as the lack of PPE and not properly secured scaffoldings were risk issues on both projects.

7.5.1.3 Risk Factors as a Result of External influences

External influences such as inflation and changes in prices of materials led to cost issues on both projects. A common characteristic of the Nigerian construction industry which is lack of transparency is also a major factor that led to risks on both projects 1 and 2 and this also led to bribery and corruption. The issue of defective materials being sold in Nigeria was also another external source of risk which and this leads to quality issues. On project two, due to the nature and size of project 2, the activities of sub-contractors was another source of risk. Delays by some sub-contractors meant delay in the overall progress of the project. Another issue which affected project 2 was hoarding of materials by some suppliers in anticipation of price increases and this caused delay on the projects. The level of competition in the industry and its effects on how contractors bid for projects also leads to risks such as cost issues.

7.5.2 The Risk Factors Peculiar to the Nigerian construction Sector

As captured on both projects, there were some sources of risks that were captured as peculiar to the Nigerian construction industry or to construction industries of developing countries in Sub-Saharan Africa. These were health and safety issues which were hardly considered or given the attention they required by the project teams. These included the wearing of personal protective equipment (PPEs), safety for working on high levels, and the environmental condition under which site teams' work. Lack of funds and difficulty in securing funds or loans from banks due to the lack of collateral is also another source of risks. Corruption, which is deemed very high in Nigeria, is also another source of risk in the construction industry which lead to cost and quality issues. Working under very harsh weather conditions was another source of risk that was identified on both projects as a common factor in the Nigerian industry. Cultural factors such as power struggle and the relationship between leaders and subordinates was seen as a source of risk which is peculiar to the Nigerian construction industry and these in some instances lead to lack of communication, and wrong decisions by project leaders.

7.6 BBN Model Modification and Conclusion

As gathered from the discussion of the Bayesian belief network model presented to the two project teams, a number of risk factors or their relationships had been ignored in the

BBN model. Combining results from the two projects, it becomes evident that there are some risk factors that may be particular to construction projects in Nigeria or developing countries that were not initially captured in the model. There are also other areas posing risks to projects that were not properly captured by the model and as such may need modification to ensure risk identification is fully captured. This section discusses the changes and makes modification to the BBN model as shown in figure 7.1.

NB: The modified BBN Model for risk management in developing countries Figure 7.1 was developed based on a modification of Figure 6.1 through a validation using live case study projects. For this reason, the sources of risk factors identified were from literature, questionnaire study and the case study projects which were largely private construction projects. In terms of the linkages between the factors, this was done by information from the case studies, and subjective judgements of the professional informed in the project execution as well as judgements from the researcher. The BBN Model is expected to be applicable to construction projects in different parts of the world but will be more suited to projects in developing countries and also private sector projects that are procured through traditional means (tender based on price competition). The BBN can be applicable to projects in other parts of the world or other types of projects i.e. civil projects (road construction projects) but must be done by making sure the project specific contexts and risk factors are taken into consideration (See Figure 7.2 for more info). The extent of influence of risk factors like lack of transparency, bribery and corruption, shortage of equipment required, political orientation, low salaries and lack of motivation, lack of protective equipment, and health and safety issues are expected to have limited influences in developed countries.

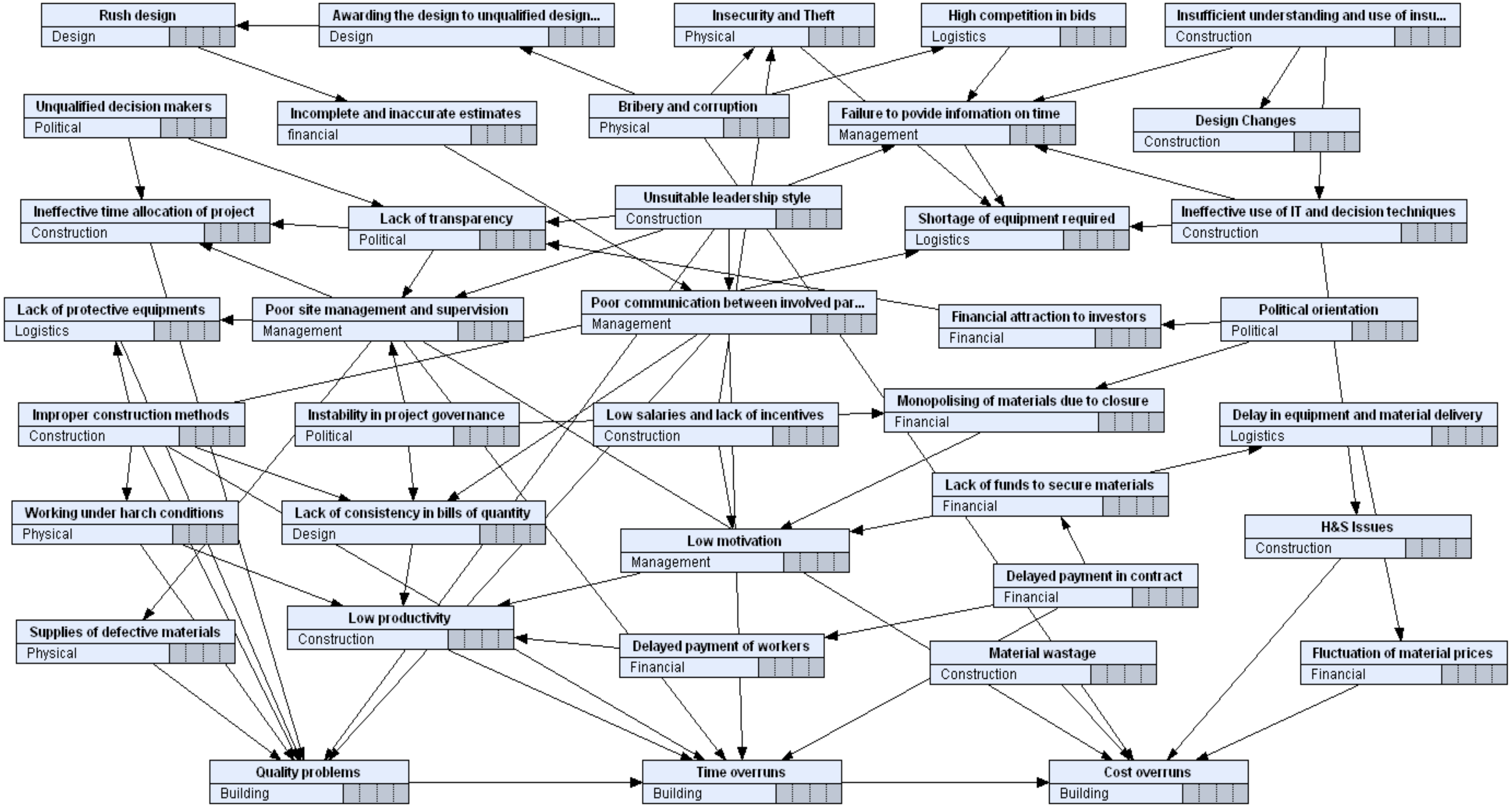


Figure 7.1: Modified Bayesian Belief Network to Support Risk Management of Building Construction Projects in Nigeria

7.6.1 Discussion of the Modified Bayesian Belief Network Model for Building Construction Projects in Nigeria

Risk Factors Causing Cost Overruns in the Nigerian Construction Sector

As shown in the preceding sections, the risk factors leading to cost as captured in the model were not conclusive and need to be amended. From the case studies, time overruns was a major factor leading to cost overruns in the Nigerian construction industry. Quality issues were also found to have a direct bearing on cost overruns especially where quality problems are detected leading to the need to redo sections of work. Improper site management was identified to lead to wastage which ultimately causes to cost overruns. New factors such as health and safety issues also contribute to cost overruns. Corruption is also a major source of cost overruns in the construction industry.

Risk Factors Causing Time Overruns in the Nigerian Construction Sector

From the discussion above, risk factors leading to time overruns were: quality problems, cost overruns, improper construction methods, delayed payments, poor communication, poor management and supervision of workers on site, and the use of obsolete construction methods. Improper construction methods, quality problems and delayed payments were the main direct causes of time overruns. Delayed payments lead to delay in the payment of workers which affects productivity. Another effect of delay payment is the lack of funds to secure materials which may also result in time overruns. Supply of defective materials lead to quality issues which may lead to time overruns when reworks occur. Delay in the delivery of materials and equipment to site affect the progress of work which also results in time overruns. Lack of motivation as a result of low salaries was found to be a major factor leading to time overruns as it affected the productivity of workers on site. Cultural issues such as the struggle for power and the attitudes of project leaders affect time overruns on projects.

Risk factors Causing Quality Problems in the Nigerian Construction Sector

Quality issues on projects results from many different sources of risks with the most direct sources being the supply of defective materials, improper construction methods, and poor communication between project team members. Consequently, risk factor such as incompetent personnel taking decisions was also another major source of risk leading to quality issues. Health and safety issues such as the lack of protective equipment and working under harsh conditions also indirectly have an effect on quality of projects. Issues such as rush design, little time allocation for projects, frequent design changes which occur as a result of client activities, poor supervision and poor site management practices. Unsuitable leadership styles, incompetent people making decisions and improper construction methods result in quality problems on projects. Improper construction methods also results from shortage of equipment and ineffective use of technology. Quality problems can also occur from working under adverse weather conditions. A summary of the building construction project risk factors in the Nigerian construction sector is presented in Table 7.6.

Table 7.6: Summary of the critical risk factors affecting building construction projects in Nigeria

Project performance	**Risk factor**
Quality Assurance problems	Supply of defective materials
	Working under harsh conditions
	Improper construction methods
	Lack of protective equipment
	Ineffective time allocation of project
	Poor communication between involved parties
	Unsuitable leadership style
Time overruns	Quality problems
	Low productivity
	Improper construction methods
	Poor communication between involved parties
	Delayed payment in contracts
	Poor site management and supervision
Cost overruns	Fluctuation of materials prices
	Health and Safety issues
	Bribery and Corruption
	Material wastage
	Poor site management and supervision
	Time overruns

7.6.2 Management of the Most Critical Risk Factors Affecting Building Construction Projects in Nigeria

As discussed in section 2.5, the essence of risk management is to be able to identify and quantify the risks inherent in any activity and put in place a management mechanism or plan to help mitigate or manage the influence of such risks on the activity. Table 7.6 above shows a summary of the critical risk factors affecting building construction projects in Nigeria. Quantification of the likelihood and impact of the risks has been done to identify their criticality to the performance of building construction projects in Nigeria. The risk acceptability measure developed in section 6.2.2 was applied to the critical risk factors identified for the Nigerian construction industry after the validation of the BBN model to support building construction projects in Nigeria. The application of the risk acceptability matrix on the final critical risk factors suggested the risks are medium to high and as such a risk control strategy must be put in place by construction companies if such risks are to be well managed and their influence on projects controlled.

7.6.2.1 Risk control for critical risk factors affecting building construction projects in Nigeria

The results from the validation indicated that majority of the risks are internal and this means contractors can put in measures to manage or prevent the occurrence of high level risks while putting in place measured to reduce the impact of medium and low risks on building construction projects. Suitable risk response strategies for critical risk factors have been identified (see section 3.9). The strategies include actions to be taken to respond to risks based on their perceived significance or acceptability as illustrated in table 3.5 (see section 3.9) as well as some positive risk responses, such as exploiting, sharing, enhancing and accepting, and other negative risk responses, such as avoidance, mitigation transfer and acceptance. Table 7.7 shows risk management options outlined for managing the critical risk factors affecting building construction projects in Nigeria.

Table 7.7: Risk response strategy

Project performance	**Risk factor**	**Proposed risk Management action required**
Quality Assurance problems	Supply of defective materials	Ensure only trusted suppliers are engaged in the supply of materials. Periodic review of suppliers to enable the company select good suppliers
	Working under harsh conditions	Proper planning of projects taking into consideration weather conditions to ensure the most appropriate conditions are provided for work. This requires regular assessment of the conditions under which site teams work to ensure maximum performance is achieved at all times.
	Improper construction methods	To avoid the problem of improper construction methods, site managers and foremen should be given regular training to enable them have current knowledge of practices in the industry and grant them the

		ability to identify wrong methods used by site teams
	Lack of protective equipment	Construction companies should ensure adequate PPE is made available to workers at all times and also workers are given the required training on site safety and the need to use protective equipment
	Ineffective time allocation of project	To ensure the problem of ineffective time allocation is managed, project planning at the initial stage of projects should be done with emphasis on allowing reasonable time on the execution of projects. this will require good method statements which will take into consideration risk factors likely to affect time on the projects
	Poor communication between involved parties	Good collaborations between involved parties (from clients, consultants and contractors) should be encouraged on all projects to ensure a common good is pursued for the project
	Unsuitable leadership style	People put in charge of managing projects or sites should be given the required leadership training to ensure building construction projects precede based on good leadership. This has to take into account local specific factors likely to affect project performance
Time overruns	Quality problems	(As identified above)
	Low productivity	The issue of productivity at the construction site can be improved through motivation of site teams and also instituting a very effective management team and style on projects.
	Improper construction methods	(ditto as above)
	Poor communication between involved parties	As above
	Delayed payment in contracts	The influence of delayed payments can be managed by ensuring issues of payment are well documented at the start of projects. Clients should be encouraged to ensure payments arrangements made are executed according to plan. Contractors may also want to put in place a backup plan to ensure the cash flow of projects are not negatively affected by delayed payments.
	Poor site management and supervision	The issue of poor site management and supervision can be managed by ensuring management team on site are given the required training and also have the required technical knowhow on the construction methods and technologies used on projects.

Cost overruns	Fluctuation of materials prices	As the problem of price fluctuation is outside the control of the project teams, procurement of materials for projects should be made well in advance of their use periods to prevent increased costs from material price increases.
	Health and Safety issues	Health and safety issues should be given the needed consideration on projects as it has a high influence on project performance. Management teams on site should have appropriate training in health and safety which will help them pass on health and safety guides on site to workers. There should be periodic tool box talks on health and safety at the project sites to ensure site teams are well equipped on health and safety issues
	Bribery and Corruption	Often the risks to construction organisations stems from corrupt practices of which it has no knowledge, undertaken by its suppliers and customers. Due diligence and careful negotiations should be required to insulate construction organisations from the wrongdoing of others. Construction companies in Nigeria should consider deploying enhanced scrutiny when entering into contracts with other parties.
	Material wastage	The issue of material wastage on projects can be managed by ensuring proper planning of material usage and also using the most appropriate methods of construction which will lead to low waste generation. This can also be checked by having good supervision of the activities of site workers.
	Poor site management and supervision	(As explained above)
	Time overruns	As above

Applying the management options provided in the table above will go a high extent to help project teams mitigate and in some cases eliminate the effects of the most critical risk factors affecting the performance of building construction projects in Nigeria. A best practice risk management system for building construction projects based on the critical risk factors is produced as a guide to managing risks on building construction projects in Nigeria is shown in Figure 7.2 and the process of implementing the guideline for building construction projects is illustrated in Table 7.8.

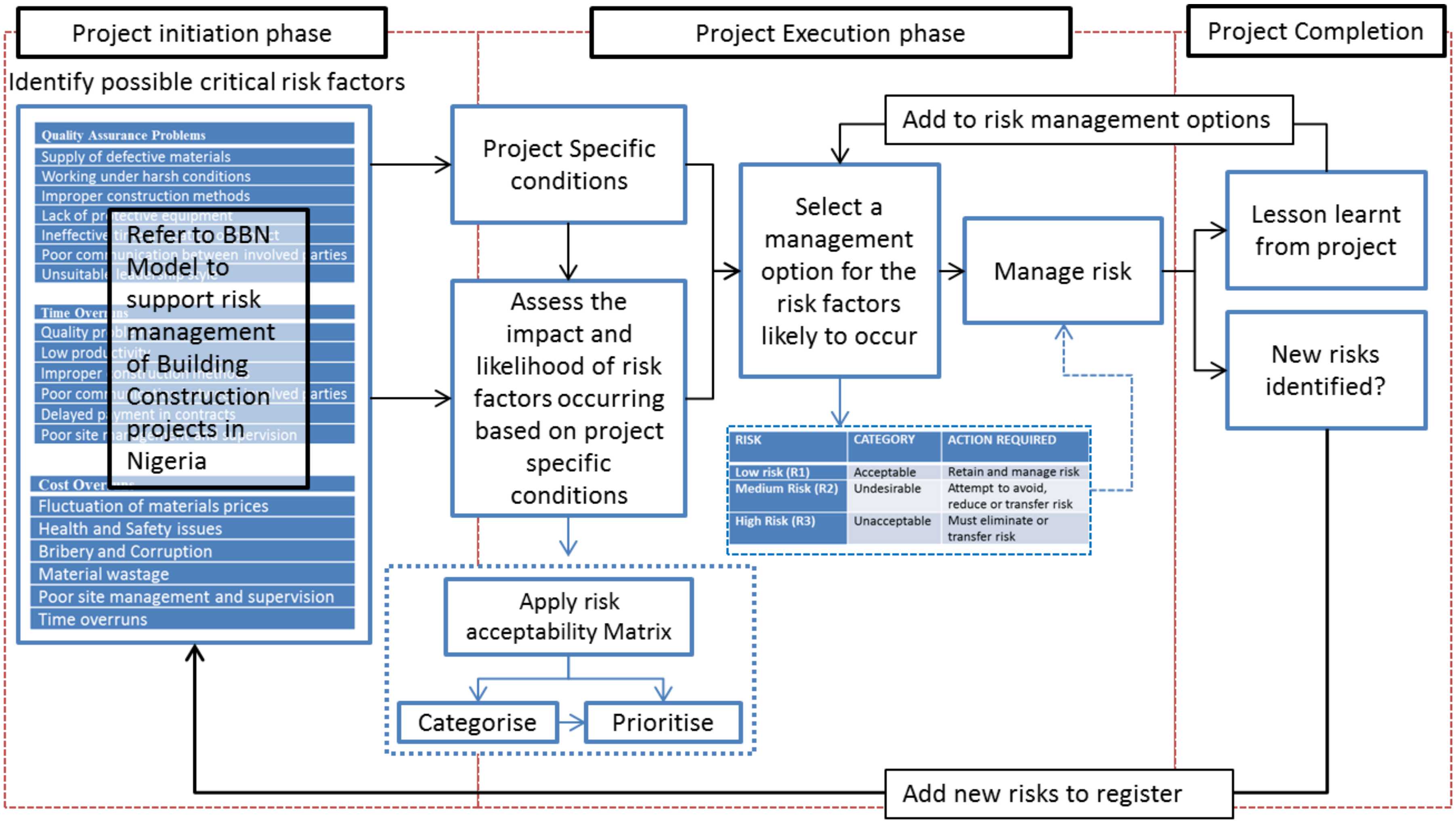


Figure 7.2 Best Practice System for Risk Management in Building Construction projects in Nigeria

Table 7.8: Guidelines for implementing Best Practice Framework for Risk Management in Building Construction projects in Nigeria

Stage of Projects	Actions required	Remarks
Project Initiation	Refer to this BBN model to identify risk factors that are likely to affect project based on project specific conditions	A Bayesian belief network model for risk management in building construction projects in Nigeria has been developed with risks likely to influence risk management in building construction projects in Nigerian and their cause and effects relationships. Information such as project sum, the type of client, duration, availability of drawings etc. to be used in selecting risk factors and conducting risk assessment
	After identification of possible risk factors, conduct risk assessment with emphasis on the impact and likelihood of risk factors occurring on the project	
	Apply a risk acceptability matrix (RAM) to categorise and prioritise risk	
Project Execution Phase	Select risk management option by conducting risk assessment and categorization.	Use information provided in the framework to determine action required based on the categorisation of the risk
	Manage risk factors based on the best practice management options	Refer to best practice management options provided in Table 7.7 for possible options
Project Completion	Capture lessons learnt from the management of the risk factors	Add the insights to the management options to serve as aid on subsequent projects
	Check if new risks factors were identified which are not listed in the BBN model, add these risks to the risk register	Update risk register anytime new risks are identified on projects

7.6.2 Internal Validation

Rosenthal and Rosnow (1991) define internal validity as the degree of validity of statements made about whether X causes Y – the primary concern being to rule out plausible rival hypotheses. Egbu (2007) notes that internal validation seeks to outline the strength of the model as well as assess the literature search. Internal validation could also be achieved through agreement of findings with published research and also through academic validation achieved via research publications. Some researchers have further demonstrated internal validation by establishing convergence between research findings, published research and academic validation. Such previous studies include Proverbs (1998), Xiao (2002) and Ankrah (2007). According to Manu (2012), this approach has been used in construction management doctoral studies in order to assess the studies against published works and subject the studies to expert scrutiny. Therefore, this section presents how this research demonstrates internal validity. Agreement of research findings with published work is described by Black (1993) and De Vaus (2002) as a criterion for validity.

Academic validation involves the dissemination of the findings of this research through seminar presentations, doctoral workshops, conferences and journal papers which are subject to peer review. A peer review of the research publications provided an opportunity for the methodologies, meanings and interpretations of research to be questioned by independent judges (Xiao 2002). Academic forums such as seminars, workshops and conferences were also used to scrutinise the research findings and receive feedback and comments which were also incorporated in the research to improve its validity. So far, in this research, the following papers have been published and presented in doctoral workshops and conferences:

Journal Papers:

1. Odimabo O.O and Oduoza C.F (2013): Risk Assessment Framework for Building Construction Projects' in Developing Countries; International Journal of Construction Engineering and Management; Vol. 2, No. 5, pp. 143-154.
2. Odimabo O.O, Oduoza C.F and Suresh S (2016): Methodology for project risk Assessment using Bayesian Belief Network for Building Construction Projects in Nigeria; ; Engineering, Construction and Architectural Management ; In view.

Conference and Doctoral Workshop Papers

1. Odimabo O.O and Oduoza C.F (2013): Risk assessment to improve management of building projects in construction firms; Proceeding from the 6th Ajman International Urban Planning Conference-City & Security; Dubai.
2. Odimabo O.O and Oduoza C.F (2014): Methodology for project risk assessment using Bayesian belief network in engineering construction projects; Proceedings from the 24th International Conference on Flexible Automation and Intelligent Manufacturing (FAIM); San Antonio, Texas.
3. Odimabo O.O, Oduoza C.F and S.Suresh (2015): Critical risk factors affecting building construction projects in Nigeria-an Empirical Study; Proceeding from the 25th International Conference on Flexible Automation and Intelligent Manufacturing; University of Wolverhampton; United Kingdom.
4. Odimabo O.O, Oduoza C.F and S.Suresh (2016): A management guide for critical risk factors affecting building construction projects in Nigeria; Proceedings from the 28th International Conference on Civil and Architectural Engineering (ICCAE); Abuja, Nigeria.
5. Odimabo O.O, Oduoza C.F and S.Suresh (2016): Risk factors affecting project performance: Evidence from Nigerian building construction project; Proceeding from the 25th International Conference on Flexible Automation and Intelligent Manufacturing; Seoul, South Korea

Seminars and Presentations

1. A presentation titled “Developing a risk management system for building construction projects in developing countries: Implication for practice” was presented at the April, 2014 Annual Progress report (APR) at School of Technology, University of Wolverhampton
2. A seminar titled “ Developing a risk management system for building construction projects in developing countries: Implication for practice” was also presented at the May, 2014 Built Environment and Engineering Research Seminars (BEERS) at School of Technology, University of Wolverhampton in respect to findings from the quantitative study.
3. A first secondment report presentation titled “Risk management software system for SMEs in the construction industry” was presented in May, 2014 at Vettorazzo Costruzioni S.R.L, Padova, Italy.

4. A presentation titled "Methodology for Project Risk Assessment using Bayesian Belief Network in Engineering Construction Projects; was presented in May, 2014 at the 24th International Conference on Flexible Automation and Intelligent Manufacturing (FAIM); University of Texas at San Antonio, Texas.
5. A seminar titled "Risk Management in the Construction Industry- RiMaCon Mid-Term report" was presented in March 2015 at Vettorazzo Costruzioni S.R.L, Padova, Italy.
6. A presentation titled "Critical risk factors affecting building construction projects in Nigeria-an Empirical Study" was also presented in June, 2015 at the 25th International Conference on Flexible Automation and Intelligent Manufacturing; University of Wolverhampton; United Kingdom.
7. A seminar titled "Risk Management in the Construction Industry- RiMaCon mid-term report" was presented in September, 2015 at the Faculty of Science and Engineering, University of Wolverhampton, United Kingdom.
8. A seminar titled "Risk Management System to Guide Building Construction Projects' in Developing Countries: A Case Study of Nigeria" was also presented at the January, 2016 Built Environment and Engineering Research Seminars (BEERS) at School of Technology, University of Wolverhampton in respect to findings from the quantitative and qualitative study.

7.7 Chapter Summary

This chapter reports on the validation of the Bayesian belief network model for building construction projects in Nigeria. The chapter describes the validation process, which includes both external and internal validation. The internal validation was based on academic validation which involved the publication of some aspects of the research findings in journals and conference proceedings. In these papers, a significant number of references have been cited to support the different arguments. Moreover, the concepts, methodology and findings of this research have been found to be reasonably supported by the extensive use of literatures in support of the study. With respect to external validation, participants were invited to share their view on the BBN model developed in this research in two case studies which was reported within this chapter. The case studies was used to identify risk factors and validate the relationships between the risk factors and how they affect project performance (cost, time and quality) as presented in the BBN model in this research. The results from the analysis of the participants responses indicate that the findings reported in the research are valid and can be generalised across building construction projects in Nigeria. This chapter also presented the outcome of this research by developing a risk management system for building practitioners in Nigeria as well as developing countries in managing risks associated to their projects and also summarised the research noting the major findings. In the next chapter, the conclusions of this research based on the analyses and validation process will be presented. The research limitations and recommendations for further research will also be put forward.

CHAPTER EIGHT: CONCLUSION AND RECOMMENDATIONS FOR FUTURE WORK

8.0 Chapter Introduction

The overriding purpose of this research is to establish a system which will improve the performance of building construction projects in developing countries, without cost and time overruns while achieving optimal quality. To accomplish this goal, it became necessary for the research to reach an understanding about the concepts and fundamental issues of risk management. It was only upon the achievement of these fundamental understandings that the research was able to go forward. This research also sought to know how the construction sector in Nigeria manages risks of building construction projects. Additionally, it focused on identifying the significant risk that affected building construction projects in Nigeria. The development of a Bayesian belief network model is used to quantify the probability of risk factors in building construction projects in Nigeria. The final outcome of the research developed a best practice risk management guide for building construction projects in Nigeria. This has resulted in several conclusions which are discussed next.

8.1 Summary of the Research Findings

Chapter one sets out the background of the research. The chapter noted that a large number of building construction projects in developing countries like Nigeria suffer from many setbacks in terms of completion of the project at stipulated time, cost overruns and quality problems. These setbacks are often responsible for turning profitable projects into loosing ventures. It suggested that the presence of an effective and efficient construction risk management function will enhance the successful completion of building construction projects and thereby make the project more profitable. However, construction risk management has not received adequate application within the building construction sector in Nigeria. A major reason to this could be the lack of a sound risk management framework. This is further compounded with the inability of the building construction industry to respond quickly to the needs of the clients which in most cases takes far longer than expected and frequently fail to meet the technical performance of building construction project. This study therefore sought to establish a system which will improve the performance of building construction projects in developing countries, without cost and time overruns while achieving optimal quality, through a comprehensive risk management model that ensures the expectations of clients. In order to address this aim, a number of objectives were identified. The discussion below summarises how the objectives were achieved.

8.1.1 The Current Level of Building Project Performance in terms of Cost, Time and Quality

To satisfy the first objective, the research first in Chapter two reviewed the theoretical principles of risk management. The basic concepts, definitions, and terminology related to risk management was critically reviewed. In addition, it highlighted the benefits of implementing a systematic risk management process for various construction stakeholders. The chapter also examined the different risk management processes as recommended by different authors to gain an awareness of the numerous stages suggested for a successful building construction risk management. Subsequently, the guidelines provided by the Institution of Civil Engineers (ICE), Association of Project Management (APM), Construction Industry Research and Information Association (CIRIA) and other researchers was critically reviewed to define the criteria required for successful risk management. A range of techniques for quantifying risk was recognized but for the purpose of this study, the Bayesian belief network (BBN) was adopted for risk management which avoids, transfers, shares, retains, reduces or ignores potential risk in a building construction environment. Hence, a construction risk management framework using Bayesian Belief Network is presented which is used in this research for building construction project.

Consequently, the causes of poor construction project performance in developing countries were reviewed in Chapter three. The literature identified the problems and provided definitions and key concepts. It showed that numerous researchers have given an extensive list of risk factors that affect construction projects generated from different sources (see section 3.3). Previous studies revealed that there is no consensus in the identification of construction risk factors. That is probably because the construction industry of any country is unique and risk factors could come from many different sources. It further identified major risks factors in building construction projects in developing countries. Seventy six (76) risk factors were identified through literature review and presented in a risk breakdown structure (RBS) (see Section 3.7). They were classified into nine (9) groups as physical, environmental, design, logistics, financial, legal, construction, political and management risk. Consequently, the risk acceptability matrix (RAM) which categorises the significance of risk as low (acceptable), medium (undesirable) and high risk (unacceptable) was also developed (see Section 3.9). The risk acceptability matrix (RAM) is adopted for a qualitative Bayesian belief network (BBN) risk assessment. The Risk Acceptability Matrix prioritise the significance of risk factors according to their position on the risk matrix with 25 ranks, utilising the difference in scales between likelihood of occurrence and impact. It furthers recommends some actions to be taken as a response to risks based on their perceived significance or acceptability.

8.1.2 The major risk factors that have significant effect on building project performance in Nigeria

To satisfy the second research objective, Chapter 4 presented how the research was designed, and data was obtained and analysed to address the research question, aims and objectives. To identify the most appropriate methodology, Chapter 4 made an extensive review of the various methodology options and identified the most suitable approach in collecting the requisite data, analysing the results and testing the validity of the findings. This was done by putting the research limitations and constraints into consideration. The quantitative study was found to be the most suitable approach in identifying major risk factors affecting building construction projects in Nigeria while the qualitative study was selected as a strategy for validating the BBN model using a sample of construction practitioners in Nigeria.

Chapter 5 presented findings from the quantitative study used to assess the seventy six (76) risk factors listed through literature. In order to determine the most significant risk factors affecting building construction projects in Nigeria, as perceived by building contractors, subcontractors and clients, descriptive statistics of the mean was used. Participants were asked to evaluate risk factors affecting building construction projects according to their experiences based on their likelihood of occurrence and impacts on projects measured on a five-point Likert scale). A criticality decision cut-off point of 3.0 and above for risk likelihood was the criteria adopted and merged with the impact of risks which then reduced the risk factors to a total of 27 variables. These 27 risk factors were identified to have significant effect on building construction performance in Nigeria. The risk acceptability matrix (RAM) was used qualitatively to determine the most critical risk that affect building construction projects in Nigeria.

8.1.3 Risk Management Model

To satisfy the third research objective, Chapter 6 presented a Bayesian belief network model based on the findings from the literature review and quantitative study to support risk management of building construction projects in Nigeria. The Bayesian belief network (BBN) consists of nodes, representing variables of the domain, and arcs, representing dependence relationships between nodes. The BBN was applied in this research to show a cause and effect relationship between risk factors in building construction projects and how they directly or indirectly affect project performance (cost, time and quality). The procedure used in developing the BBN model for building construction projects was done under the following main themes: identification of risk factors; qualitative risk assessment for BBN; construction of the BBN model; and risk control (sensitivity analysis). From the BBN model developed, the risk factors that directly caused quality problems were improper construction methods, poor communication between involved parties on the project and supplies of defective materials. Risk factors that caused time overruns were quality problems, cost overruns, improper construction methods, poor communication between involved parties and delayed payments. Risk factors that affected cost overruns were fluctuation of material prizes and unsuitable leadership style in building construction projects in Nigeria. The Bayesian belief network is proposed for building construction risk assessment in this research because they allow inference based on observation and calculate conditional probabilities of risk factors.

8.1.4 Validation of the model using data from live building construction projects.

To fully satisfy the fourth research objective, Chapter 7 presented findings from the validation process and the outcome of the study. The entire research findings were validated using an external and internal validation processes. External validity was achieved in this research by allowing construction practitioners to share their views on the BBN model in two case studies. The case studies was used to identify risk factors and validate the relationships between the risk factors and how they affect project performance (cost, time and quality) as presented in the BBN model. The research used data from three main sources to validate the BBN model for risk identification and management on building construction projects. They are; interviews, documentary evidence and site observations. The results from the analysis of the participants responses indicate that the findings reported in the research are valid and can be generalised across building construction projects in Nigeria. The feedback received is generally encouraging and suggests that the BBN model has the potential of being well received. The outcomes suggest that the BBN model useful in terms of managing risk factors that are associated with the building construction sector in Nigeria. Consequently, to fully satisfy the purpose of this research, a risk management system was developed to guide building practitioners in Nigeria to manage building construction related risks. The risk management system consists of 3 parts: the project initiation phase, where possible risk factors are identified, the project execution phase where assessment of risk factors is undertaken and managed and the project completion phase that generate the desired output.

On the other hand, the internal validation was established through agreement between past studies and the research findings and also through academic validation of the research publications (see Section 7.6.2).

8.2 Contribution to Knowledge

Throughout the work undertaken in this research, several contributions have been made to the existing body of knowledge and understanding. The main areas of this contribution to knowledge in building construction risk management practice is summarised as follows;

1. **Developed methodology for project risk assessment using BBN for building construction projects in Nigeria**

   This research has contributed to exciting body of knowledge by introducing and adopting BBN as a novel research methodology that goes beyond the normal explanatory or descriptive or traditional research methodologies in Nigeria. BBN was adopted for the modelling of building construction risk analysis that represents risk factors and their conditional relationships graphically as nodes and linkages in an influence diagram for the Nigerian building construction environment. The Nigerian construction environment as identified in chapter 3 is characterised by characterised by poor quality work, cost and time overruns. These characteristics originate because a number of risk factors (especially those peculiar to the Nigerian building construction industry) have not been properly taken into consideration in the project planning and implementation stage. Hence, the BBN methodology developed in this study is based on knowledge and experiences acquired from experts who are in a position to provide information on the sources of uncertainty, and the causes of uncertain condition with a view to generate optimal response strategies to support a successful building project outcome.

2. **Proposed improvements to risk management construction practice within the case organisations**

   This contribution relates to the practical benefit realised within case studies 1 and 2. This was achieved through active collaboration between the research and the study organisation. Consequently, the outcomes from the case studies suggested the BBN model useful in terms of managing risk factors that are associated with the building construction sector in Nigeria.

3. **Established a cause and effect relationships of risk factors affecting building construction performance in a BBN model**

   Another major contribution to this research is the rich insight gained in chapter 6 on the cause and effect relationships of risk factors and how they lead to cost overruns, time overruns and quality problems in a typical building construction project. As seen from the previous sections, the BBN model supports risk management for building construction projects. The risks factors were analysed to determine how they resulted in cost overruns, quality assurance issues and time overruns on projects. In the Nigerian context, risk factors leading to quality problems were improper construction methods, poor communication between stakeholders on the project, and supply of defective materials in building construction projects. Risk factors leading to time overruns were also identified to be quality problems, cost overruns, improper construction methods, poor communication between involved parties and delayed payments for contracts. Cost overruns were found to be linked directly to fluctuation of material prizes and unsuitable leadership style in building construction projects in Nigeria.

4. **Developed a risk management system that will serve as a guide for the successful completion of building construction projects in Developing countries using Nigeria as case country**

   It is observed from literatures that no research has put forward a risk management system that will guide construction practitioners to manage risk in the Nigerian construction environment. Therefore, this research is considered a pioneer study in the development of a risk management system that will guide construction practitioners in Nigeria in improving the performance of building construction projects in Nigeria, without cost and time overruns while achieving optimal quality. From the findings of the research, the risk management guide provides a dynamic view of the critical risk factors that affect building construction projects and how they can be successfully managed in the Nigerian construction environment. In a nutshell, a properly implemented risk management process will enhance the successful completion of building construction projects and thereby make the project more profitable.

5. **Proposals for risk responses**

   Building construction practitioners should be familiar with the major causes of poor project performance in Nigeria, and plan to avoid or lessen their impact. Hence, this research put forward effective mitigation actions to eliminate or alleviate the significant risk events before they take place. An additional contribution of this research to knowledge is, therefore, declared through the establishment of a set of recommendations to construction practitioners (represented in section 7.6.2). The proposed countermeasure actions are aimed at minimising the causes of poor project performance and hence improve the performance of building construction project management.

Practical contribution:

Consequently, the findings of the research as it has progressed have been published in peer-reviewed international journals and presented and at international conferences and published as proceedings. The publications will enforce the research in the Nigerian construction sector and academic institutions and will encourage professionals, and particularly academicians, to open a new area of research.

8.3 Research Limitations

Any research may include some limitations due to different reasons specially the limited time frame for conducting this kind of study.

One limitation of this research is the fact that the collection of empirical data depended mainly on the level of access that was granted to the researcher. Therefore, the participants could have hidden some vital information from the researcher, which could possibly have improved the research outcome, without the researcher's knowledge.

The study was limited to construction organisations in Port Harcourt, Yenagoa and Owerri cities of Nigeria. It is the researcher's belief that although the research was limited to these cities nevertheless, some of the research findings are likely to be similar to those in other parts of Nigeria. However, the present research findings cannot be generalised without additional research. Similarly, despite the fact that issues concerning construction organisations in Nigeria are homogeneous, it is still difficult to generalise Nigeria's results to other developing countries of the world without conducting additional research.

Another limitation is the validation of the BBN model in only two construction projects, being handled by indigenous construction companies.

The researcher notes that results of data gathered from the various participants was analysed by only one person. Hence, another researcher may interpret the participants' views or the research results in a different way.

8.4 Recommendations

A set of recommendations that will assist construction practitioners to manage the most significant risk factors have been highlighted in chapter seven. Additional recommendations that will help Nigerian construction industry as well as other developing countries in minimising risks inherent in building construction projects are provided in this following section.

8.4.1 Recommendations for the Nigerian Construction Sector

The following are the recommendations for construction professionals in the Nigerian construction sector;

- Construction professionals working in the Nigerian building construction sector should adopt and implement the risk management system developed in this research. Putting the system into practice will enable local and foreign companies to systematically identify and assess the risk factors affection building construction projects. This will help to better understand the major risks associated with these kinds of projects, and consequently plan and undertake effective risk mitigation measures to curtail the risks before they happen.

- At the early stage of building construction projects, it is essential that effective decisions on building construction budget, timely issuing of information, finalisation of design and project management skills should be the main focus of the parties involved in project procurement process. This helps in eliminating future disputes and variations between parties during the construction stage. On the other hand, risk management successfully installed in building construction projects offers the chance to gain a clear understanding of the goal, duties and contents of the service and feasibility of the project.
- Building construction organisations that wish to apply this risk management system should engage its staff in construction risk management seminars, workshop or a training session to acquire all necessary knowledge and skills required to achieve its smooth implementation. The training should also be an avenue where adequate guide will be given to construction workers in implementing the system.
- A good knowledge of the benefits of risk assessment techniques and the ability to adopt them in promoting risk management in building construction projects should be an essential requirement when recruiting project managers, site managers in local and international construction organisations.

8.4.2 Recommendations for Future Research

The following are the recommendations in respect to future research;

- In practical terms, construction organisations in developing countries as well as in Nigeria should provide integrated training containing knowledge of risk management for construction practitioners. This should become part of a well-defined approach to risk management, and it requires more experts in risk management who can provide both general and specific training of various kinds to ensure that effective risk response processes are developed.
- The BBN model should be used with more real-life cases in construction projects that have experienced delay. Observations carried out in this study related to the case studies with senior construction practitioners in the industry revealed that they find it comfortable discussing about construction risk, and

hence, more information was forthcoming. Hence, more research could be undertaken with project staff to enhance the knowledge and understanding in the area.

- Generally, project managers perceive the BBN model as being suitable to support risk management in building construction projects. However, some of them believe the BBN model is too resource-intensive for small projects. Therefore, in addition to the BBN model, attention should be given to the development of regulations to ensure process integration and optimisation in Nigeria.
- There should be focus on investigating both aspects of the risk (positive: opportunity and negative: threat) while studying risk management of construction projects in Nigeria.

8.5 Overall Conclusion

An investment in building construction projects is not without risks. A large number of building construction projects in developing countries as well as in Nigeria suffer from many setbacks in terms of completion of the project at stipulated time, cost overruns and quality problems. These setbacks are often responsible for turning profitable building projects in developing countries into loosing ventures.

In this research, the different ways in which risk management process improves building construction projects performance were identified on an extensive critical literature and empirical evidence from construction organisations using a quantitative study. In identifying the significant risk factors that affect building construction projects in Nigeria, seventy six risk factors were identified through literature review and classified into nine (9) groups as physical risks, environmental risks, design risk, logistics risks, financial risks, legal risks, construction risks, political risks and management risk. A questionnaire survey was conducted of randomly selected samples and responses from 343 construction professionals was drawn from 305 contractors/subcontractors and 38 clients or owners (private and public) within the Nigerian construction sector. The respondents assessed each risk factor based on their likelihood of occurrence and impact on projects using a five point scale. Response data was subjected to descriptive statistics and subsequently, the risk acceptability matrix (RAM) was adopted to categorise and prioritise risk factors in order to identify the key critical risks factors in building construction projects in Nigeria. A total of 27 risk factors were ascertained based on a comprehensive qualitative risk assessment of the magnitude of their impact and likelihood of occurrence using the RAM. A Bayesian belief network model was further developed by structural learning and used to examine the cause and effect relationship amongst the 27 critical risk factors. The BBN model developed is used to support risk management of building construction projects in Nigeria. Determination of the relationship between the risk factors in the BBN model was done through subjective judgement of the researcher based on the review of literature on risk factors affecting building construction projects and also on the results from the data collected on risk factors in the Nigerian construction sector. The developed BBN model was further subjected to validation using a multiple case study of two ongoing building construction projects in Nigeria. The result showed the interrelation between the 27 risk factors and how they contributed to cost overruns, times overruns and quality problems. As a result of the validation process, the critical risks directly affecting the cost of building construction project were found to be fluctuation of material prices; health and safety issues; bribery and corruption; material wastage; poor site management and supervision; and time overruns. The critical factors identified to directly affect quality were identified to be: supply of defective materials; working under harsh conditions; improper construction methods; lack of protective equipment; ineffective time allocation; poor communication between involved stakeholders; and unsuitable leadership style. Time overruns on building construction projects was directly caused by: quality problems; low productivity; improper construction methods; poor communication between involved parties; delayed payments in contracts; and poor site management and supervision. The results from the validation indicated that majority of the critical risks are internal and this means contractors can put in measures to manage or prevent the occurrence of high level risks while putting in place measured to reduce the impact of medium and low risks on building construction projects. Suitable risk response strategies for critical risk factors were suggested. The strategies include actions to be taken to respond to risks based on their perceived significance or acceptability as well as some positive risk responses, such as exploiting, sharing, enhancing and accepting, and other negative risk responses, such as avoidance, mitigation transfer and acceptance.

The findings from this research were used to establish a risk management system that guides building construction practitioners to improve the performance of building construction projects in Nigeria as well as developing countries, without cost and time overruns while achieving optimal quality. Furthermore, in a building construction project where cost, time and quality really matters, executing a project within the specified budget, time frame and optimal quality is critical, therefore properly implementing a risk management process will enhance the successful completion of building construction projects and thereby making the project more profitable.

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APPENDICES

APPENDIX A: Developing Countries

The list of developing countries shown below is adhered to by the ISI, effective from 1 January till 31 December 2015. Developing countries are defined according to their Gross National Income (GNI) per capita per year. Countries with a GNI of US$ 11,905 and less are defined as developing (specified by the World Bank, 2013).

Afghanistan	Guatemala	Pakistan
Albania	Guinea	Palau
Algeria	Guinea-Bisau	Panama
Angola	Guyana	Papua New Guinea
Argentina	Haiti	Paraguay
Armenia	Honduras	Peru
Azerbaijan	India	Philippines
Bangladesh	Indonesia	Romania
Belarus	Iran, Islamic Rep.	Rwanda
Belize	Iraq	Samoa
Benin	Jamaica	São Tomé and Principe
Bhutan	Jordan	Senegal
Bolivia	Kazakhstan	Serbia
Bosnia and Herzegovina	Kenya	Seychelles (Transitional)
Botswana	Kiribati	Sierra Leone
Brazil	Korea, Dem Rep.	Solomon Islands
Bulgaria	Kosovo	Somalia
Burkina Faso	Kyrgyz Republic	South Africa
Burundi	Lao PDR	South Sudan
Cabo Verde	Lebanon	Sri Lanka
Cambodia	Lesotho	St. Lucia
Cameroon	Liberia	St. Vincent and the Grenadines
Central African Republic	Libya	Sudan

Chad	Macedonia, FYR	Suriname
China	Madagascar	Swaziland
Colombia	Malawi	Syrian Arab Republic
Comoros	Malaysia	Tajikistan
Congo, Dem. Rep	Maldives	Tanzania
Congo, Rep.	Mali	Thailand
Costa Rica	Marshall Islands	Timor-Leste
Côte d'Ivoire	Mauritania	Togo
Cuba	Mauritius	Tonga
Djibouti	Mayotte	Tunisia
Dominica	Mexico	Turkey
Dominican Republic	Micronesia, Fed. Sts.	Turkmenistan
Ecuador	Moldova	Tuvalu
Egypt, Arab Rep.	Mongolia	Uganda
El Salvador	Montenegro	Ukraine
Eritrea	Morocco	Uzbekistan
Ethiopia	Mozambique	Vanuatu
Fiji	Myanmar	Vietnam
Gabon	Namibia	Palestine, State of
Gambia, The	Nepal	Yemen, Rep.
Georgia	Nicaragua	Zambia
Ghana	Niger	Zimbabwe
Grenada	**Nigeria**	

Countries that are slightly over the amount of US$ 11,905 will be considered a developing country for the year 2015 and their situation will be reviewed for 2016.

The names of the countries are based upon United Nations sources.

The designations employed and the presentation of country or area names in this list do not imply the expression of any opinion whatsoever on the part of the ISI concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

APPENDIX B: Probability and Statistics Symbols Table

Symbol	Symbol Name	Meaning / definition	Example
$P(A)$	probability function	probability of event A	$P(A) = 0.5$
$P(A \cap B)$	probability of events intersection	probability that of events A and B	$P(A \cap B) = 0.5$
$P(A \cup B)$	probability of events union	probability that of events A or B	$P(A \cup B) = 0.5$
$P(A \mid B)$	conditional probability function	probability of event A given event B occurred	$P(A \mid B) = 0.3$
$f(x)$	probability density function (pdf)	$P(a \le x \le b) = \int f(x)\, dx$	
$F(x)$	cumulative distribution function (cdf)	$F(x) = P(X \le x)$	
μ	population mean	mean of population values	$\mu = 10$
$E(X)$	expectation value	expected value of random variable X	$E(X) = 10$
$E(X \mid Y)$	conditional expectation	expected value of random variable X given Y	$E(X \mid Y=2) = 5$
$var(X)$	variance	variance of random variable X	$var(X) = 4$
σ^2	variance	variance of population values	$\sigma^2 = 4$
$std(X)$	standard deviation	standard deviation of random variable X	$std(X) = 2$
σ_X	standard deviation	standard deviation value of random variable X	$\sigma_X = 2$
$\tilde{x}$	median	middle value of random variable x	$\tilde{x} = 5$
$cov(X,Y)$	covariance	covariance of random variables X and Y	$cov(X,Y) = 4$
$corr(X,Y)$	correlation	correlation of random variables X and Y	$corr(X,Y) = 0.6$
$\rho_{X,Y}$	correlation	correlation of random variables X and Y	$\rho_{X,Y} = 0.6$

$\sum$	summation	summation - sum of all values in range of series	$\sum_{i=1}^{4} x_i = x_1 + x_2 + x_3 + x_4$
$\sum\sum$	double summation	double summation	$\sum_{j=1}^{2}\sum_{i=1}^{8} x_{i,j} = \sum_{i=1}^{8} x_{i,1} + \sum_{i=1}^{8} x_{i,2}$
Mo	mode	value that occurs most frequently in population	
MR	mid-range	$MR = (x_{max} + x_{min}) / 2$	
Md	sample median	half the population is below this value	
Q_1	lower / first quartile	25% of population are below this value	
Q_2	median / second quartile	50% of population are below this value = median of samples	
Q_3	upper / third quartile	75% of population are below this value	
x	sample mean	average / arithmetic mean	$x = (2+5+9) / 3 = 5.333$
s^2	sample variance	population samples variance estimator	$s^2 = 4$
s	sample standard deviation	population samples standard deviation estimator	$s = 2$
z_x	standard score	$z_x = (x-x) / s_x$	
$X \sim$	distribution of X	distribution of random variable X	$X \sim N(0,3)$
$N(\mu,\sigma^2)$	normal distribution	Gaussian distribution	$X \sim N(0,3)$
$U(a,b)$	uniform distribution	equal probability in range a,b	$X \sim U(0,3)$
$exp(\lambda)$	exponential distribution	$f(x) = \lambda e^{-\lambda x}$, $x \geq 0$	
$gamma(c, \lambda)$	gamma distribution	$f(x) = \lambda\, c\, x^{c-1} e^{-\lambda x}$ / $\Gamma(c)$, $x \geq 0$	
$\chi^2(k)$	chi-square distribution	$f(x) = x^{k/2-1} e^{-x/2}$ / ($2^{k/2}\,\Gamma(k/2)$)	
$F(k_1, k_2)$	F distribution		
$Bin(n,p)$	binomial distribution	$f(k) = {}_nC_k\, p^k (1-p)^{n-k}$	

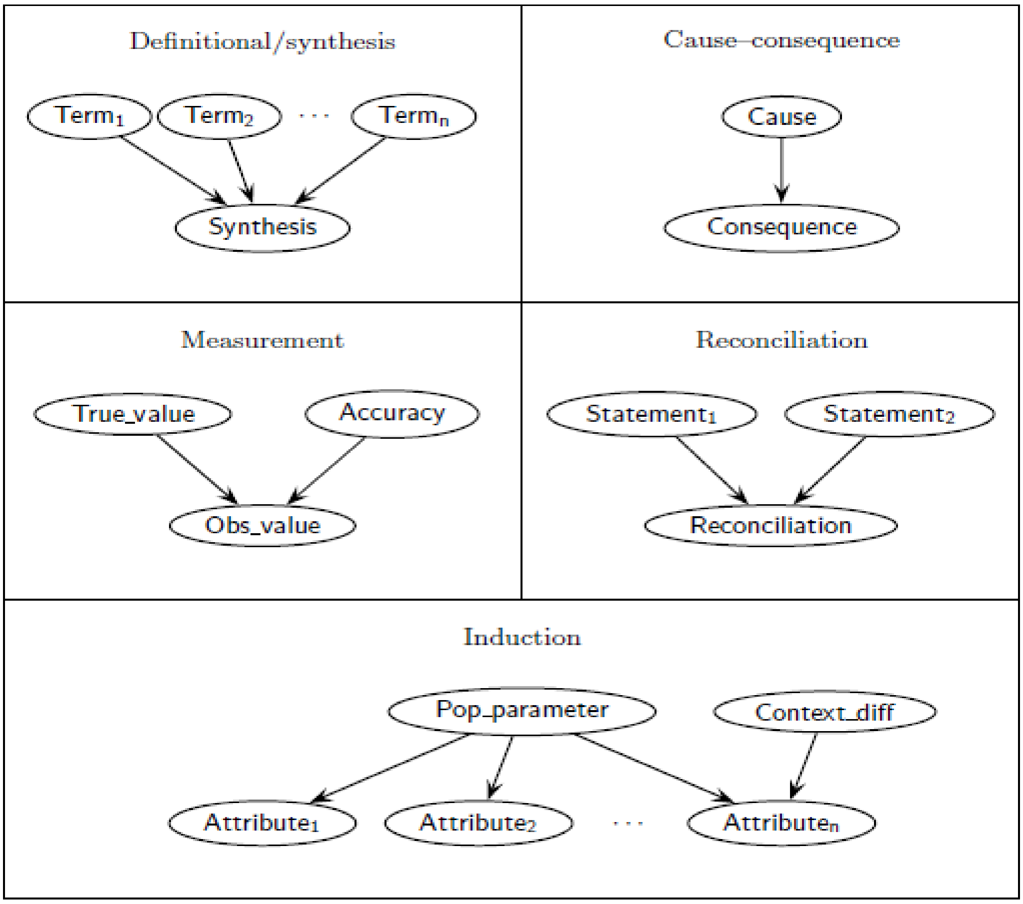
Poisson(λ)	Poisson distribution	$f(k) = \lambda^k e^{-\lambda} / k!$	
Geom(*p*)	geometric distribution	$f(k) = p(1-p)^k$	
HG(*N*,*K*,*n*)	hyper-geometric distribution		
Bern(*p*)	Bernoulli distribution		

Combinatorics Symbols

Symbol	Symbol Name	Meaning / definition	Example
$n!$	factorial	$n! = 1\cdot2\cdot3\cdot\ldots\cdot n$	$5! = 1\cdot2\cdot3\cdot4\cdot5 = 120$
${}_nP_k$	permutation	${}_nP_k = \frac{n!}{(n-k)!}$	${}_5P_3 = 5! / (5-3)! = 60$
${}_nC_k$ $\binom{n}{k}$	combination	${}_nC_k = \binom{n}{k} = \frac{n!}{k!(n-k)!}$	${}_5C_3 = 5!/[3!(5-3)!]=10$

APPENDIX C: Understanding Model Structure in the Large-scale Network

The BBN structure can be constructed manually. The identification of probability network structure is not as simple as it might be using a normal qualitative graph (Kjaerulff and Madsen, 2008). Therefore, modellers need to understand the structured approach to network structure identification in order to ground a basic knowledge, particularly in the large-scale BBN. Neil et al. (2000) proposed the following idioms as an approach to eliciting the BBN structure in order to support the building of the BBNs, see Figure A-1. Suggestions for selecting the correct idiom were provided by Kjaerulff and Mansen (2008), as shown by Figure A-2.



Source: Kjaerulff and Madsen, 2008; Neil et al., 2000

Figure A-1 Types of model structure (idioms)

1. Definitional/synthesis

This idiom aims to structure the BBN by linking many variables into one variable such as defining in deterministic or uncertain definition or function from different terms. This idiom is the same as the **divorcing technique** (Appendix F.1) used to reduce the number of condition probability.

2. Cause-consequence

This idiom aims to structure the BBN model in the casual process as the relationship between cause and effect variables. It can sometimes represent the prediction from input(s) to output(s).

3. Measurement

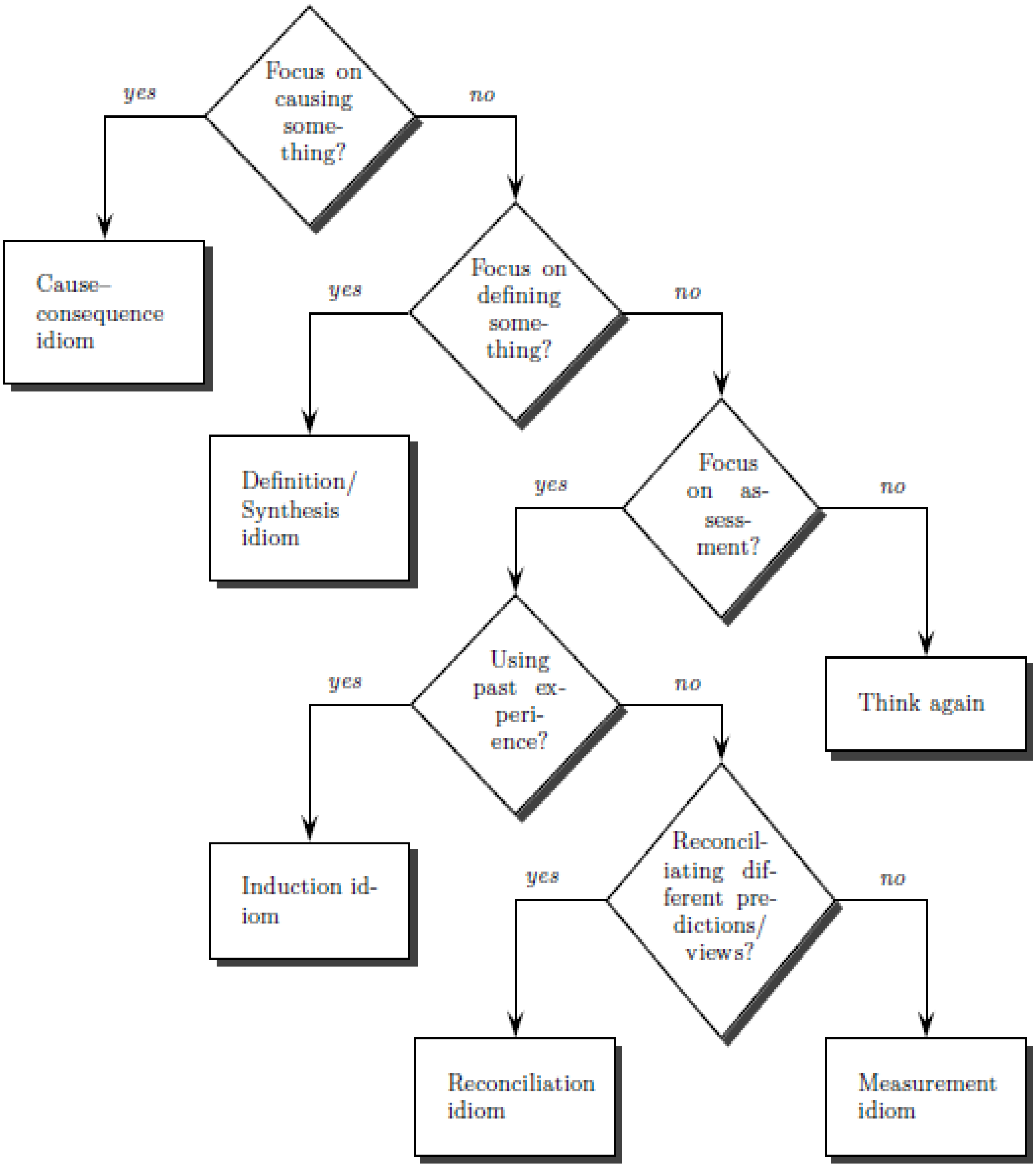
This idiom can represent the uncertain of accuracy via measurement, so the value of the model can be compared with the actual value to measure accuracy from historical data. One variable can represent an estimator of other variables.

4. Reconciliation

This idiom can represent the competitive statements that arise from different sources or methods of information.

5. Induction

Induction is the model process of statistical inference from a series of similar entities to a future or unobserved entity with similar attribute, but there is no reasoning in terms of cause and effect.



Source: Kjaerulff and Madsen, 2008; Neil et al., 2000

Figure A-2 Flowchart of criteria to choose the right idiom

APPENDIX D: Questionnaire

Please mark boxes as follows ☒

Section 1: General Information

1. Name: ☐

2. Email: ☐

3. Company: ☐

4. Contact address: ☐

5. Your profession

Civil Engineer ☐ Architect ☐ Quantity Surveyor ☐

Othes, specify…………..

6. How long have you worked in the construction industry?

1 year to 5 years ☐ 6 years to 10 years ☐ 11 years to 15 years ☐

16 years to 20 years ☐ 21 years to 25 years ☐ Over 25 years ☐

7. Did you study risk management or/and project management courses? Yes ☐ No ☐

If yes, what courses? ☐

8. Do you encounter any risk in your projects (e.g. delayed payments, handling of chemical hazards, etc.) Yes ☐ No ☐

9. How do you evaluate your knowledge of risk management? Low ☐ Fair ☐ Advanced ☐

10. Name of the contruction project ☐

10a.Your role in the project:

Contractor ☐

Sub-contractor ☐

Other, namely: ☐

Section 2: Contractors/Sub-contractor Information and Risk Management in the different Phases of the Project

Any construction process can be divided into four main phases: Project inception, design, construction and project completion. This section of the questionnaire explores the aspects of the risk management process through the different phases. Risk management in the project consists of risk identification, risk assessment and risk response. The aim of risk management is to maximise opportunities and minimise consequences of a risk event.

1. How many years has your firm been in business?

Less than 1 year ☐ 1 year to 5 years ☐ 6 years to 10 years ☐

11 years to 20 years ☐ 21 years to 40 years ☐ Over 40 years ☐

2. What is the number of projects you have been awarded over the last three (3) years?

None ☐ 1 to 5 projects ☐ 6 to 25 projects ☐

26 to 50 projects ☐ 51 to 100 projects ☐ Over 100 projects ☐

3. How do you evaluate the project implementation in terms of the following parameters? (Tick off the most appropriate alternative for each parameter)

	Very bad	Fairly bad	Fairly good	Very good
Quality	☐	☐	☐	☐
Cost	☐	☐	☐	☐
Time	☐	☐	☐	☐

4. If time and cost overrun occur constantly in your projects, please state the reason(s)?
………
………
………
……………………………………………………………………………

5. In what phases of the project did you participate?
(Tick off your answer)

Project inception ☐
Design ☐
Construction ☐
Project completion ☐

6. Does your company perform risk management? Yes ☐ No ☐

6a. If your company performs risk management, please state what technique does it use?
………
……………………………………………………………………………………………

6b. Where the following risk management processes carried out systematically in the project?

	Yes	No
Risk identification	☐	☐
Risk assessment	☐	☐
Risk response	☐	☐

6c. If your company does not perform risk management, please state why?
………
………

7. In what phases of the project were the risk management processes performed?
(Tick off one or more alternatives that are suitable in every process)

	Inception	Design	Construction	Completion
Risk identification	☐	☐	☐	☐
Risk assessment	☐	☐	☐	☐
Risk response	☐	☐	☐	☐

8. Did you participate in risk management? Yes ☐ No ☐

8b. If yes, what was your role in risk management (e.g. risk identifying, risk assessing, risk mitigation)?

9. What are your perception about the following impacts of risk on your company?

Risk group	**Low**	**Medium**	**High**
Physical risk (e.g. supplies of defective materials)			
Environmental risk (e.g. flood)			
Logistics risk (e.g undifined scope of working)			
Design risks (e.g. Defective design, innaccurate quantities, etc.)			
Financial risk (e.g.delayed payment in contract)			
Political and legal risks (e.g. new governmental acts or issues with legislation etc.)			
Mangement risk (e.g Poor resource management)			
Construction risk (e.g. rush bidding)			

10. How large influence did the project actors have on risk management?
(Tick off the most appropriate alternative for each actor)

	Very small	Fairly small	Fairly large	Very large
Client	☐	☐	☐	☐
Contractor	☐	☐	☐	☐
Suppliers	☐	☐	☐	☐

11. Assess the importance of risk management in the different phases of the project.
(Tick off the most appropriate alternative for each phase)

	Unimportant	Not so important	Fairly important	Very important
Project inception	☐	☐	☐	☐
Design	☐	☐	☐	☐
Construction	☐	☐	☐	☐
Project completion	☐	☐	☐	☐

12. Have you identified risks that resulted in problems occurring in the construction project?

Yes ☐ No ☐

12a. If yes, what impact on the project cost and time did they have?

Very small ☐ Fairly small ☐ Fairly large ☐ Very large ☐

12b. If yes, what type of risk?

12c. If yes, how were the problems were solved?

13. To what extent do you believe that performing risk management enhances the ability of your company to achieve the project goals of time, cost, and quality?

Very high ☐ High ☐ Moderate ☐
Low ☐ Very Low ☐ No benefit ☐

16. To what extent do you believe that providing risk management software will improve the performance of construction project for your company?

Very high ☐ High ☐ Moderate ☐
Low ☐ Very Low ☐ No benefit ☐

SECTION 3: Identification and Assessment of the Risk Factors

Please assess the following risk factors qualitatively based on your knowledge and experience on the past three (3) years.

Fill the two columns utilizing the attached risk assessment tables.

Impact	*Description*	*Scale Value*
Extreme	Project could not be sustained (e.g. bankruptcy)	5
Great	Serious threat on project	4
Moderate	Medium effect on project	3
Little	Small effect on project	2
Negligible	Trivial effect on project	1

Table 1: Term for quantifying impact

Likelihood	*Description*	*Scale Value*
Frequent	Very frequent occurrence	5
Probable	Likely to occur regularly	4
Occasional	Quite often occurs	3
Rarely	Small likelihood but could well happen	2
Improbable	Unlikely but possible	1

Table 2: Terms for quantifying likelihood.

Risk group	*Risk factors*	*Risk likelihood*	*Risk impact*
Physical risk	***Supplies of defective materials***		
	Fluctuation of material prices		
	Low productivity of equipment		
	Shortages of materials required		
	Insecurity and Theft		
	Bribery and Corruption		

	Vandalism		
Environmental risk	***Environmental factors (flood, earthquake, etc.)***		
	Rain effect on construction activities		
	Hot weather effects on construction activities		
	Difficulty to access the site (very far, settlements)		
Design risk	***Defective design (incorrect)***		
	Not coordinated design (structural, mechanical, electrical, etc.)		
	Inaccurate quantities		
	Lack of consistency between bill of quantities, drawings and specifications		
	Rush design		
	Shortages of qualified firms		
	Awarding the design to unqualified designers		
Logistics risk	***Shortage of skilled labour***		
	Low productivity of labour		
	Fluctuation of labour prices		
	Delay in equipment delivery		
	Shortage of equipment required		
	Failure of equipment and unavailability of spare parts		
	Undefined scope of working		
	High competition in bids		
	Poor communication between the home and field officers (contractors side)		
	Inaccurate project program		
Financial risk	***Delayed payment in contracts***		
	Incomplete or inaccurate estimates		
	Incomplete documentation for the delivery of the project		
	Financial attraction of project to investors		
	Financial failure of the contractor		
	Unmanaged cash flow		
	Exchange rate fluctuation		
	Monopolizing of materials due to closure and other unexpected political conditions		

	Difficulty to get permit		
	Inflation and sudden changes in prices		
Legal risk	***Legal disputes during the construction phase among the parties of the contract***		
	Delayed dispute resolutions		
	Requirement to use local labour		
	Ineffective enforcement of rules and regulation		
	Frequent changes and modification in law		
	No specialized arbitrators to help settle fast		
Construction risk	***Rush bidding***		
	Lack of experienced people involved in technical studies, estimating, and scheduling		
	Lack of database in estimating activity duration and cost		
	Lack of coordination and communication between various parties		
	Ineffective use of information technology and decision making techniques		
	Inadequate overall company structure		
	Improper construction methods		
	Proper quality, health, and safety management		
	Insufficient understanding and use of insurance policy		
	Low salaries and lack of incentives and motivations for project personnel		
	Unsuitable leadership style		
	Shortage of qualified and specialised companies		
	Unavailability of specialised companies for sophisticated work packages		
	Gaps between the implementation and the specification due to misunderstanding and specification		
	Undocumented change orders		
	Lower work quality in presence of time constraints		
	Design changes		
	Actual quantities differ from the contract quantities		
Political risk	***Unqualified decision makers***		
	Instability in project governance		
	Lack of transparency		

	Political orientation		
	New governmental acts or legislations		
	Unstable security circumstances (invasion)		
	closure		
Management risk	***Ambiguous planning due to project complexity***		
	Resource management		
	Changes in management ways		
	Unavailability of contractors pre-qualification system		
	Unqualified owners representatives		
	Slowness of the owners decision making process causing suspension of work		
	Information unavailability (include uncertainty)		
	Failure to provide documents and information on time		
	Poor site management and supervision		
	Poor communication between involved parties		

Add your comments and suitable risk factor where needed.

Your comments about constructions sector risks and/or questionnaires would be appreciated:
……
……
……
……
……
……
……

Thank you for your assistance in this research. Please be assured that, while you will be considered as a respondent, your individual contribution will be kept anonymous and in the strictest confidence.

APPENDIX E: Covering Letter

ONENGIYEOFORI ODIMABO
Faculty of Science and Engineering,
University of Wolverhampton,
Wulfruna Street,
WV1 1LY,
Tel: +447778088356
Email: O.Odimabo@wlv.ac.uk
United Kingdom
Date: 09/09/2014

Dear Participant;

A QUESTIONNAIRE SURVEY ON RISK MANAGEMENT IN BUILDING CONSTRUCTION PROJECTS

I am a doctoral researcher at the University of Wolverhampton. As a part of my programme I am carrying out a research titled "RISK MANAGEMENT SYSTEM TO GUIDE BUILDING CONSTRUCTION PROJECTS' IN DEVELOPING COUNTRIES: A CASE STUDY OF NIGERIA". The intended outcome will be a risk management model which will improve the performance of building construction projects in Developing Countries. A copy of this will be sent free to all participants. It is being undertaken under the supervision of Prof. C.F Oduoza of the University of Wolverhampton, United Kingdom.

Completion of the attached questionnaire will take approximately 20 minutes, and all questions can be answered by following the simple instructions. Completion of the questionnaire is completely voluntary. ALL RESPONSES ARE ANONYMOUS, there are no correct or incorrect answers and respondents who take part will not be identifiable. If results of this study are published they will be a summary of all responses to ensure that your privacy is protected.

Should you choose to complete the questionnaire, please return it in the enclosed stamped self-addressed envelope by post. By returning the questionnaire in this manner YOUR ANONYMITY IS ENSURED, so please use no identifiable markings. Returning this questionnaire will be considered as your consent to participate in the survey.

Once completed a summary of results will be available at the conclusion of the academic year. If you wish to obtain a copy of these results, please provide your contact details. Please note that all data gathered for this research will be stored securely and destroyed after the dissertation has been submitted. My supervisor and I will be the only people who will have access to this data.

Thank you for taking time to consider this invitation and if you choose to participate in this research I would like to extend my personal gratitude; your contribution is greatly appreciated.

Yours Faithfully,

Onengiyeofori Odimabo
Doctoral Researcher

Risk Management Definitions and Terminology

To ensure uniform understanding about the topic, brief definitions and terminology related to risk management are provided below;

Risk: An uncertain event or set of circumstances that, should it occur, will have an effect on the achievement of the project's objectives.

Risk in Construction: A potential event that is either internal or external to a project that, if it occurs, may cause the project to fail to meet one or more of its objectives.

Risk Management Process: Risk management is a cyclical process, which is made up of the following critical steps: Risk identification, qualitative risk assessment, quantitative risk analysis, risk response.

Risk Analysis: this refers to the assessment and synthesis of the risks affecting a project to gain an understanding of their individual significance and their combined impact upon the project's objectives, as a basis for determining priorities for the application of risk responses.

Risk Likelihood (Probability): The degree of belief or confidence that a respondent believes about the frequency of occurrence of a risk factor, based on his intuitive and subjective judgment. Hence, risk likelihood can be ranked as frequent, probable, occasional, rarely and improbable.

Risk Impact (Consequences): What is the extent a risk factor affects the project performance should this risk occur. This is elicited on the basis of respondent's experience and subjective judgment. Thus, risk consequences can be ranked as extreme, great, moderate, little and negligible.

Risk Acceptability: Is concerned with the amount of risk that a contractor is facing. Risk acceptability, also called risk exposure, includes two components, namely, the likelihood of occurrence (the risk probability) and consequences (risk impact). Risk acceptability is defined as the product of risk probability and risk impact: risk acceptability = risk probability x risk impact.
Depending on the total amount of risk that a contractor is facing, individual risks can be classed as unacceptable, undesirable, acceptable, and negligible.

Questionnaire Sections

1- General information;
2- Contractor information and performance on previous projects;
3- Identification and assessment of the main risk factors

Please, answer all questions if possible and provide the following information in the sequence and format by this questionnaire template

APPENDIX F: Ethics Form

UNIVERSITY OF WOLVERHAMPTON
SCHOOL OF TECHNOLOGY

ETHICAL CONSIDERATION FOR RESEARCH PROGRAMMES

Section 1: Your details			
First Name & Surname:	Onengiyeofori Odimabo	**Student No:**	1133441
Project Title	RISK MANAGEMENT SYSTEM TO GUIDE BUILDING CONSTRUCTION PROJECTS' IN DEVELOPING COUNTRIES: A CASE STUDY OF NIGERIA		
Director of Studies:	Professor Chike F Oduoza		

Section 2: Your Project Topic	
2.1 What problem is this project addressing? (100 words or less) The primary aim of this research is to establish a system which will improve the performance of building construction projects in developing countries, without cost and time overruns while achieving optimal quality, through a comprehensive risk management model that ensures the expectations of clients are met.	
2.2 Will information or artefacts resulting from your project be available externally to the University?	Yes
2.2.1 **If you answered 'yes' to 2.2,** Will any such information place anyone at risk or possibly result in any action that might be detrimental to their wellbeing? (See guidelines)	No. The information obtained is strictly for academic purposes and poses no risk to the well- being of participants as stated in Section 1: Category A1 of the ethics approval guidelines. Electronic copy of dissertation to be kept in the learning centre and could be accessed by others but no confidential information, such as transcribed excerpts will be included.
2.2.2 In what format will the information or artefacts be made available?	Publications in academic journals, conference proceedings and databases such as Ethos and WIRE.

Please attach samples with this form if you intend to do interviews, surveys, or questionnaires.	
3.1 Does any part of your proposed project involve human participants?	Yes **If 'no' proceed to section 4**

3.2 Please explain any aspects of the project, which might be detrimental to the wellbeing of any human participants in your project.
No aspect of this project is detrimental to the wellbeing of human participants. Interviews will be codified for data protection purposes, and anonymity of questionnaire respondents would be ensured through the use of unmarked envelopes or direct collection from respondents.
3.3 Are there other ways you might meet your project aims without involving human participants? If not, why?
No other ways. This is basically because my research involves individual perceptions to the attributes of satisfaction, and the level to which Government construction projects have not offered such satisfaction through the quality of its construction projects. This information can only be obtained from human participants, hence the selected approach using these participants. **3.4** How will you select your participants?
Participants will be selected based on their relevance to the Government construction project under investigation. Contracting firms would be obtained from the database of the ministry of works. Multi stage cluster sampling of respondents would cater for the quantitative data gathering, while Judgemental/ purposeful sampling would be employed while obtaining qualitative data. This would include developing a framework of variables to influence participation in addition to the demographic stratification of age, gender and social class.
3.5 How many participants will you contact? About 1500 participants (Interviews 12 and questionnaires 650).
3.6 How will you approach potential participants? E.g. email, letter, face to face? Please append text of any letter or email? Participants for the interviews The database of contracting firms to Government projects would be obtainable from the Rivers State of Nigeria ministry of works, and relevant firms would be contacted through mail, e-mail and face to face depending on proximity of the organisation. Non-contracting participants (customers) would be contacted through interactions with the host communities of the project location, potential students and hospital staff in the case of the hostel accommodation and hospital buildings considered. Consent of the interviewees would be sought at the beginning of each interview while a declaration to participate in the research through the questionnaire survey would be obtained by a return of the completed questionnaire.
3.7 Are your participants adults? (over 18 and competent to give consent) If no, answer 3.7.1. (See guidelines) Yes.

3.7.1	

Are your participant's children or adults under 18 and not competent to give consent? If yes, why is it necessary to involve these participants?	No.
3.8 Are you offering any incentives to any of your participants, financial or otherwise? (See guidelines)	No.
3.9 How much time do you estimate will be needed from any participants? (See guidelines)	Interviews- 45 Minutes per participant Questionnaires- 30 Minutes per participant
3.10 Please list the method of data collection and analysis intended to be used ➢ Mixed method; Questionnaires and case studies ➢ Analysis of interview data would involve categorization, pattern identification and theme creation through the Nvivo Software. ➢ Analysis of questionnaire data would involve the statistical tool SPSS to identify correlations, regressions and importance of the attributes investigated.	
3.11 Will all of the data collected contribute towards your results?	Yes.

Section 4: Confidentiality and data handling	
Please read methods of ensuring confidentiality in the guidelines.	
4.1 Will you ensure the anonymity of data collected from/and about participants?	Yes
4.1.1 Please explain how this will be achieved.	
Codes to represent respondents would be developed. For example, CS001, CS002, for respondents 1, 2, respectively. Also, the use of unmarked envelopes for postal communication wold be employed.	
4.2 Will you store/protect data collected from individuals e.g. password protected files?	Yes
4.3 Once your project is complete and information is no longer needed, will you destroy your data?	Yes
4.4 Will anyone else have access to the data collected?	Yes
If so, (i) please name the individuals and/or groups that will have	Prof C.F Oduoza (DOS)

access; (ii) why is access being given to those listed in (i)?	Dr Subashini Suresh. They are my supervisors.

Section 5: Working with other parties and companies	
5.1 Will you be using data on subjects held by another party or organisation?	No
If Yes, (i) Please give details. (ii) How will you gain access to this information?	
5.2 Do you require written permission from a company, organisation or location, e.g. an employer or local authority?	No
If Yes, (i) Please complete an external agreement form and include this with your submission.	
NB: If working with another organisation or company please familiarise yourself with their Health & Safety procedures.	

Things you must be aware of:

Data Protection Act: http://www.ico.gov.uk/what_we_cover/data_protection.aspx
Freedom of Information Act:
http://www.opsi.gov.uk/Acts/acts2000/ukpga_20000036_en_1
University of Wolverhampton Ethical Approval Procedural Guidelines

Checklist:

1. If you are using a questionnaire or interview sheet please include a list of sample questions with your submission.
2. In addition, please include an introductory cover letter stating some information about you, your project proposal and how your data will be used.
3. If you are undertaking a project involving a company or organisation you will need to show that you have approval from that organisation. Please include a completed copy of the External Agreement Form.

Student's Declaration Sign and date against **one** declaration **only you need to sign one of these**	
Category 0. My project involves no human participation except for myself and I agree to ensure that any information or artefact produced will not be available outside the University.	
Category A1. My project involves limited human participation and I agree to ensure that (i) any such participation is not detrimental in any way to the interests of the participants; (ii) all information collected as a part of the project will be handled in accordance with the answers that I gave to question **4**; (iii) No information or artefacts which may place anyone at risk or be detrimental to their wellbeing will be made available outside the University.	
Category A2. My project involves human participation and may present some risk to participants. I have considered alternative means of pursuing the project which do not entail this risk but believe that there is no practicable alternative. I agree to ensure that I take all necessary steps to minimise risks to participants and third parties. I agree not to proceed with any activities involving human participation until I have received approval from the Department Ethics Panel.	
Category B-E. My project does not conform to Category 0, A1 or A2. I have considered alternative means of pursuing the project which do not entail risk to human participants but believe that there is no practicable alternative to the proposal made. I agree to ensure that I take all necessary steps to minimise risks to participants. I agree not to proceed with any activities involving human participation until I have received approval from the School or University Ethics Committee, as appropriate.	

Director of Studies/Principal Investigator's Declaration Sign and date against **one** declaration **only**	
Category 0 or A1. I concur with the classification of this project as **0** or **A1** and authorise continuation of the project pending consideration by the School Ethics Committee	
Other. I believe that this project should be classified other than **0** or **A1.** I will ensure that no activities involving human participants take place until and unless approval is granted by the School Ethics Committee	

FOR SUPERVISOR/PANEL/COMMITTEE USE ONLY:

<table>
<tr><td colspan="9">CLASSIFICATION ALLOCATED BY SUPERVISOR</td></tr>
<tr><td>0, A1</td><td></td><td colspan="6">Supervisor Action: Authorise and forward to SEC   Date</td><td></td></tr>
<tr><td rowspan="17">Other</td><td></td><td colspan="6">Supervisor Action: Refer to DEP for decision   Date</td><td></td></tr>
<tr><td colspan="8">CLASSIFICATION ALLOCATED BY SCHOOL ETHICS COMMITTEE</td></tr>
<tr><td>0, A1</td><td></td><td colspan="5">SEC Action: Continuation of project approved   Date</td><td></td></tr>
<tr><td rowspan="13">A2, B</td><td></td><td colspan="5">Considered by SEC below   Date</td><td></td></tr>
<tr><td colspan="3">2.3 Is any risk associated with access to project acceptable in context? If no, give reasons below:</td><td>Yes</td><td></td><td>No</td><td></td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="3">3.1 Is involvement of human participants justified? If no, give reasons below:</td><td>Yes</td><td></td><td>No</td><td></td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="3">3.3 Is experimental method acceptable with regard to risk and inconvenience to participants? If no, give reasons below:</td><td>Yes</td><td></td><td>No</td><td></td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="3">4 Are arrangements for confidentiality and data protection appropriate? If no, give reasons below</td><td>Yes</td><td></td><td>No</td><td></td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="3">5 Do arrangements for working with external bodies protect interests of participants and the external bodies? If no, give reasons below</td><td>Yes</td><td></td><td>No</td><td></td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">SEC Action: Continuation of project approved: Yes   No   Date</td></tr>
<tr><td colspan="7">Conditions:</td></tr>
<tr><td>Other</td><td></td><td colspan="5">SEC Action: Refer to University Ethics Committee   Date</td><td></td></tr>
</table>

Guidelines

Section 1: Categorisation for ethical approval
Category 0: There are no third parties directly involved in the project and any artefacts produced by the project will not be accessible to a general audience.
Category A1
Projects involving human volunteers are involved solely for the purposes of:
- providing data to inform the specification of an artefact
- testing the usability or fitness for purpose of an artefact

where the nature of that artefact or its use will present no risk to the volunteers and, if any artefact is accessible to a general audience, access to that artefact will present no risk.
Category A2
Projects involving human volunteers other than those defined in category A1 but not in activities defined in other categories or if any artefact is accessible to a general audience, access to that artefact may present some risk.
Category B
Projects involving human volunteers including potential risk, for instance, studies using new research methodologies, studies involving certain vulnerable populations or therapeutic interventions or other significant risk to anyone involved in the research (but not including trials of artefacts intended for therapeutic purposes).
Category C
Research being conducted by staff or postgraduate research students involving Patients, clients staff, records etc. within the sphere of the NHS, Social Services, etc. (but not including clinical trials of medicinal or related products).
Category D
Research being conducted by undergraduate or taught postgraduate students involving Patients, clients staff, records etc. within the sphere of the NHS, Social Services, etc. (but not including clinical trials of medicinal or related products).
Category E
Clinical trials of medicinal or related products involving patients or healthy volunteers as direct users of the product.

Question 2.2.1: You should answer yes if your artefact, product or information might be of direct risk or might lead or encourage people to alter their behaviour in a way which would be detrimental to them. Examples of direct potential risk might be a machine that could injure someone if it malfunctioned or a web resource which contained information which if it was misused would lead to risk (for instance, children's identities or addresses). Examples of artefacts which might encourage detrimental behaviour could be a web resource offering alternatives to expert (such as GP or lawyer) advice or products which purport to have a therapeutic effect.

Question 3.7.: As a general principle, all participants should be informed of their role in the experiment and freely consent (in writing) to it, which implies competence to give consent. Very occasionally it may be necessary to undertake an experiment without consent, or with participants who are not competent but then any decision about the acceptability of the proposal would be taken on the basis of the absolute benefit of the experiment in a wider context, and it would have to be established that there was no alternative.

Question 3.8: With regard to freedom of consent, it likely that this principle would be breached of the participants were subject to some kind of inducement or coercion, however minor. For instance, it is likely that participants who were under the management of the person undertaking the experiment would be considered to be under a degree of coercion.

Question 3.9: It may be considered that expecting a participant to spend undue time or effort participating in an experiment would be detrimental to the interests of that person, particularly where the results of the work offered no clear benefits. It may be appropriate to compensate participants for their time, but it is not acceptable to offer inducements to participate.

Section 4 Anonymity:

It is to be expected that due care and attention be paid to protecting information about individuals. Depending on the nature of the experiment, the following may be considered.

- Type 1: Complete anonymity of participants (i.e., You will not meet, or know the identity of participants, as they are part of a random sample and are required to return responses with no form of personal identification)?

- Type 2: Anonymised samples or data (i.e., an irreversible process whereby identifiers are removed from data and replaced by a code, with no record retained of how the code relates to the identifiers. It is then impossible to identify the individual to whom the sample of information relates)?

- Type 3: De-identified samples or data (i.e., a *reversible* process whereby identifiers are replaced by a code, to which you retain the key, in a secure location)?

- Type 4: Subjects being referred to by pseudonym in any publication arising from the project?

- Type 5: Any other method of protecting the privacy of participants? (eg. use of direct quotes with specific, written permission only; use of real name with specific, written permission only)

APPENDIX G: Cover Letter for Interviews/Consent Form

ONENGIYEOFORI ODIMABO
Faculty of Science and Engineering,
University of Wolverhampton,
Wulfruna Street,
WV1 1LY,
Tel: +447778088356
Email: O.Odimabo@wlv.ac.uk
United Kingdom
Date: 25/06/2015

Dear Sir/Madam;

I am a doctoral researcher at the University of Wolverhampton. As a part of my programme I am carrying out a research titled “RISK MANAGEMENT SYSTEM TO GUIDE BUILDING CONSTRUCTION PROJECTS’ IN DEVELOPING COUNTRIES: A CASE STUDY OF NIGERIA”. The intended outcome will be a risk management model which will improve the performance of building construction projects in Nigeria. It is being undertaken under the supervision of Prof. C.F Oduoza of the University of Wolverhampton, United Kingdom.

I would be very grateful if you could participate in an interview regarding this research. Please indicate your willingness to participate in this exercise by signing and returning the declaration below. Thank you.

Yours faithfully,
Onengiyeofori Odimabo
(PhD student)

Declaration:

I wish to be interviewed. I understand that any information I provide will remain strictly confidential and only for the purpose of this research.

Signature………………………………………...

Organisation……………………………………..

Preferred date of interview……………………….

Preferred time of interview……………………….

Return to…………………………………………..

By…………………………………………………

APPENDIX H: Interview Questions for Project leaders

Interviewee information

INF 1) What is your position in the firm? ……………………………..
INF 2) How long have you been working with this firm? …………………….
INF 3) What role/s do you play on construction projects? ....

Identification of risk on project

1) Could you please give an overview of the current project?
   a. Does the nature of the project render it susceptible to any risks?

2) Is there a specific person on this project in charge of risk identification and or management?
   a. If so, that do they do? (If there is no body, how is risk management tackled on the project?)

3) Based on your experience, how likely is it that this project will be delivered on time?
   a. What factors do you think has accounted for this?

4) Is this project likely to complete within the initial budget?
   a. What factors make you say so?

5) Will the project be able to deliver the level of quality expected or anticipated from the design stage?
   a. What accounts for this?

6) In terms of risk of completing the project to time, quality, and cost expectations which of these three is the project very likely to suffer from?
   a. What specific factors on this project (from inception to the current stage) do you think pose a risk to completing this project to time, quality and cost expectations?
   b. Is it possible to tell me the relationship between these factors?

7) Was your company involved during the design phase of the project?
   a. Were there any design issues that pose a risk to the project completing on time, within budget and to the required quality?
8) A model for typical risks on a project is provided. Based on your experience in the construction industry, can you help identify the cause and effect relationships between the factors?

APPENDIX I: Analysis of Results using SPSS

One-way

Descriptive

	Profession	N	Mean	Std. Deviation	Std. Error
Quality	Civil Engineer	84	3.1905	.89814	.09800
	Architect	87	3.3563	.76214	.08171
	Quantity Surveyor	50	3.4000	.57143	.08081
	Others	122	3.3115	.84386	.07640
	Total	343	3.3061	.80361	.04339
Cost	Civil Engineer	84	3.3452	.57023	.06222
	Architect	87	3.2644	.57989	.06217
	Quantity Surveyor	50	3.2800	.49652	.07022
	Others	122	3.2459	.59351	.05373
	Total	343	3.2799	.57004	.03078
Time	Civil Engineer	84	3.1310	.74088	.08084
	Architect	87	3.1379	.74977	.08038
	Quantity Surveyor	50	3.0400	.72731	.10286
	Others	122	3.0164	.76042	.06885
	Total	343	3.0787	.74707	.04034

Descriptive

		95% Confidence Interval for Mean			
		Lower Bound	Upper Bound	Minimum	Maximum
Quality	Civil Engineer	2.9956	3.3854	1.00	4.00
	Architect	3.1939	3.5188	1.00	4.00
	Quantity Surveyor	3.2376	3.5624	2.00	4.00
	Others	3.1602	3.4627	1.00	4.00
	Total	3.2208	3.3915	1.00	4.00

Cost	Civil Engineer	3.2215	3.4690	2.00	4.00
	Architect	3.1408	3.3880	2.00	4.00
	Quantity Surveyor	3.1389	3.4211	2.00	4.00
	Others	3.1395	3.3523	2.00	4.00
	Total	3.2193	3.3404	2.00	4.00
Time	Civil Engineer	2.9702	3.2917	1.00	4.00
	Architect	2.9781	3.2977	1.00	4.00
	Quantity Surveyor	2.8333	3.2467	1.00	4.00
	Others	2.8801	3.1527	1.00	4.00
	Total	2.9994	3.1581	1.00	4.00

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Quality	Between Groups	1.787	3	.596	.922	.430
	Within Groups	219.070	339	.646		
	Total	220.857	342			
Cost	Between Groups	.521	3	.174	.532	.661
	Within Groups	110.611	339	.326		
	Total	111.131	342			
Time	Between Groups	1.083	3	.361	.645	.587
	Within Groups	189.792	339	.560		
	Total	190.875	342			

One-way

Descriptive

	Project role	N	Mean	Std. Deviation	Std. Error
Quality	Contractor	61	3.3770	.63676	.08153
	Sub-contractor	92	3.0761	1.09176	.11382
	Others	152	3.3750	.68872	.05586
	Clients	38	3.4737	.50601	.08209

	Total	343	3.3061	.80361	.04339
Cost	Contractor	61	3.3115	.64655	.08278
	Sub-contractor	92	3.2283	.49399	.05150
	Others	152	3.3092	.58946	.04781
	Clients	38	3.2368	.54198	.08792
	Total	343	3.2799	.57004	.03078
Time	Contractor	61	3.0164	.86587	.11086
	Sub-contractor	92	3.0652	.64287	.06702
	Others	152	3.1250	.75741	.06143
	Clients	38	3.0263	.75290	.12214
	Total	343	3.0787	.74707	.04034

Descriptive

		95% Confidence Interval for Mean			
		Lower Bound	Upper Bound	Minimum	Maximum
Quality	Contractor	3.2140	3.5401	1.00	4.00
	Sub-contractor	2.8500	3.3022	1.00	4.00
	Others	3.2646	3.4854	1.00	4.00
	Clients	3.3074	3.6400	3.00	4.00
	Total	3.2208	3.3915	1.00	4.00
Cost	Contractor	3.1459	3.4771	2.00	4.00
	Sub-contractor	3.1260	3.3306	2.00	4.00
	Others	3.2147	3.4037	2.00	4.00
	Clients	3.0587	3.4150	2.00	4.00
	Total	3.2193	3.3404	2.00	4.00
Time	Contractor	2.7946	3.2382	1.00	4.00
	Sub-contractor	2.9321	3.1984	1.00	4.00
	Others	3.0036	3.2464	1.00	4.00
	Clients	2.7788	3.2738	1.00	4.00
	Total	2.9994	3.1581	1.00	4.00

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Quality	Between Groups	6.963	3	2.321	3.679	.012

	Within Groups	213.894	339	.631		
	Total	220.857	342			
Cost	Between Groups	.507	3	.169	.518	.670
	Within Groups	110.624	339	.326		
	Total	111.131	342			
Time	Between Groups	.684	3	.228	.406	.749
	Within Groups	190.191	339	.561		
	Total	190.875	342			

Univariate Analysis of Variance

Between-Subjects Factors

		Value Label	N
PROFESSION	1.00	Civil Engineer	84
	2.00	Architect	87
	3.00	Quantity Surveyor	50
	4.00	Others	122
PROJECT ROLE	1.00	Contractor	61
	2.00	Sub-contractor	92
	3.00	Others	152
	4.00	Clients	38

Descriptive Statistics

Dependent Variable: Likelihood

PROFESSION	PROJECT ROLE	Mean	Std. Deviation	N
Civil Engineer	Contractor	57.5000	7.59848	20
	Sub-contractor	56.4483	5.74199	29
	Others	57.1515	6.11413	33
	Clients	59.0000	2.82843	2
	Total	57.0357	6.25453	84
Architect	Contractor	57.7273	5.33087	11
	Sub-contractor	56.2564	6.29000	39
	Others	55.3889	6.88799	36

	Clients	65.0000	.	1
	Total	56.1839	6.44751	87
Quantity Surveyor	Contractor	56.5000	6.27606	10
	Sub-contractor	55.8462	6.84161	13
	Others	57.3200	6.47251	25
	Clients	54.5000	7.77817	2
	Total	56.6600	6.40666	50
Others	Contractor	53.7000	5.39103	20
	Sub-contractor	53.8182	5.05605	11
	Others	56.3276	5.35212	58
	Clients	56.0606	6.32426	33
	Total	55.5984	5.65197	122
Total	Contractor	56.1311	6.41996	61
	Sub-contractor	55.9674	6.02641	92
	Others	56.4474	6.07436	152
	Clients	56.3684	6.25331	38
	Total	56.2536	6.12037	343

Tests of Between-Subjects Effects

Dependent Variable: Likelihood

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	168.684[a]	6	28.114	.747	.612
Intercept	726430.574	1	726430.574	19306.744	.000
Profession	154.025	3	51.342	1.365	.253
Project role	56.241	3	18.747	.498	.684
Error	12642.249	336	37.626		
Total	1098225.000	343			
Corrected Total	12810.933	342			

a. R Squared = .013 (Adjusted R Squared = -.004)

Post Hoc Tests
PROFESSION

Multiple Comparisons

Likelihood
Scheffe

(I) PROFESSION	(J) PROFESSION	Mean Difference (I-J)	Std. Error	Sig.
Civil Engineer	Architect	.8518	.93830	.844
	Quantity Surveyor	.3757	1.09565	.990
	Others	1.4374	.86967	.436
Architect	Civil Engineer	-.8518	.93830	.844
	Quantity Surveyor	-.4761	1.08857	.979
	Others	.5855	.86075	.927
Quantity Surveyor	Civil Engineer	-.3757	1.09565	.990
	Architect	.4761	1.08857	.979
	Others	1.0616	1.03001	.786
Others	Civil Engineer	-1.4374	.86967	.436
	Architect	-.5855	.86075	.927
	Quantity Surveyor	-1.0616	1.03001	.786

Based on observed means.
The error term is Mean Square (Error) = 37.626.

Multiple Comparisons

Likelihood
Scheffe

(I) PROFESSION	(J) PROFESSION	95% Confidence Interval	
		Lower Bound	Upper Bound
Civil Engineer	Architect	-1.7845	3.4882
	Quantity Surveyor	-2.7027	3.4542
	Others	-1.0062	3.8809
Architect	Civil Engineer	-3.4882	1.7845

	Quantity Surveyor	-3.5347	2.5825
	Others	-1.8329	3.0040
Quantity Surveyor	Civil Engineer	-3.4542	2.7027
	Architect	-2.5825	3.5347
	Others	-1.8324	3.9557
Others	Civil Engineer	-3.8809	1.0062
	Architect	-3.0040	1.8329
	Quantity Surveyor	-3.9557	1.8324

Based on observed means.
The error term is Mean Square (Error) = 37.626.

Homogeneous Subsets

Likelihood

Scheffe[a,,b,,c]

PROFESSION	N	Subset 1
Others	122	55.5984
Architect	87	56.1839
Quantity Surveyor	50	56.6600
Civil Engineer	84	57.0357
Sig.		.547

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = 37.626.

a. Uses Harmonic Mean Sample Size = 77.526.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. TProfessione I error levels are not guaranteed.

c. Alpha = .05.

PROJECT ROLE

Multiple Comparisons

Likelihood
Scheffe

(I) PROJECT ROLE	(J) PROJECT ROLE	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Contractor	Sub-contractor	.1638	1.01281	.999	-2.6820	3.0095
	Others	-.3162	.92971	.990	-2.9284	2.2960
	Clients	-.2373	1.26766	.998	-3.7990	3.3245
Sub-contractor	Contractor	-.1638	1.01281	.999	-3.0095	2.6820
	Others	-.4800	.81026	.950	-2.7566	1.7966
	Clients	-.4010	1.18285	.990	-3.7245	2.9224
Others	Contractor	.3162	.92971	.990	-2.2960	2.9284
	Sub-contractor	.4800	.81026	.950	-1.7966	2.7566
	Clients	.0789	1.11251	1.000	-3.0469	3.2048
Clients	Contractor	.2373	1.26766	.998	-3.3245	3.7990
	Sub-contractor	.4010	1.18285	.990	-2.9224	3.7245
	Others	-.0789	1.11251	1.000	-3.2048	3.0469

Based on observed means.
The error term is Mean Square (Error) = 37.626.

Homogeneous Subsets

Likelihood

Scheffe[a,,b,,c]

PROJECT ROLE	N	Subset
		1
Sub-contractor	92	55.9674
Contractor	61	56.1311
Clients	38	56.3684
Others	152	56.4474
Sig.		.977

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square(Error) = 37.626.

a. Uses Harmonic Mean Sample Size = 66.492.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. TProfessione I error levels are not guaranteed.

c. Alpha = .05.

Univariate Analysis of Variance

Between-Subjects Factors

		Value Label	N
PROFESSION	1.00	Civil Engineer	84
	2.00	Architect	87
	3.00	Quantity Surveyor	50
	4.00	Others	122
PROJECT ROLE	1.00	Contractor	61
	2.00	Sub-contractor	92
	3.00	Others	152
	4.00	Clients	38

Descriptive Statistics

Dependent Variable: Impact

PROFESSION	PROJECT ROLE	Mean	Std. Deviation	N
Civil Engineer	Contractor	68.0000	5.06796	20
	Sub-contractor	67.0345	6.22485	29
	Others	65.2727	5.75148	33
	Clients	71.0000	.00000	2
	Total	66.6667	5.77976	84
Architect	Contractor	66.3636	3.77552	11
	Sub-contractor	65.8462	5.04474	39
	Others	66.1667	5.28340	36
	Clients	74.0000	.	1
	Total	66.1379	5.00273	87
Quantity Surveyor	Contractor	67.1000	4.67737	10
	Sub-contractor	64.6923	7.18081	13
	Others	66.9600	5.45038	25
	Clients	64.0000	5.65685	2
	Total	66.2800	5.75358	50
Others	Contractor	64.0000	4.82319	20
	Sub-contractor	63.6364	4.94515	11
	Others	66.5000	4.97450	58
	Clients	65.5758	4.75020	33
	Total	65.5820	4.94572	122
Total	Contractor	66.2459	4.89781	61
	Sub-contractor	65.7935	5.76754	92
	Others	66.2303	5.27831	152
	Clients	66.0000	4.88240	38
	Total	66.0904	5.28935	343

Tests of Between-Subjects Effects

Dependent Variable :Impact

Source	TProfessione III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	94.629[a]	6	15.771	.559	.763
Intercept	999515.272	1	999515.272	35449.904	.000
PROFESSION	81.759	3	27.253	.967	.409
PROJECT ROLE	33.202	3	11.067	.393	.758
Error	9473.570	336	28.195		
Total	1507771.000	343			
Corrected Total	9568.198	342			

a. R Squared = .010 (Adjusted R Squared = -.008)

Post Hoc Test
PROFESSION

Multiple Comparisons

Impact
Scheffe

(I) PROFESSION	(J) PROFESSION	Mean Difference (I-J)	Std. Error	Sig.
Civil Engineer	Architect	.5287	.81224	.935
	Quantity Surveyor	.3867	.94845	.983
	Others	1.0847	.75284	.557
Architect	Civil Engineer	-.5287	.81224	.935
	Quantity Surveyor	-.1421	.94233	.999
	Others	.5560	.74511	.906
Quantity Surveyor	Civil Engineer	-.3867	.94845	.983
	Architect	.1421	.94233	.999
	Others	.6980	.89163	.893

Others	Civil Engineer	-1.0847	.75284	.557
	Architect	-.5560	.74511	.906
	Quantity Surveyor	-.6980	.89163	.893

Based on observed means.
The error term is Mean Square (Error) = 28.195.

Multiple Comparisons

Impact
Scheffe

(I) PROFESSION	(J) PROFESSION	95% Confidence Interval	
		Lower Bound	Upper Bound
Civil Engineer	Architect	-1.7534	2.8109
	Quantity Surveyor	-2.2782	3.0515
	Others	-1.0306	3.2000
Architect	Civil Engineer	-2.8109	1.7534
	Quantity Surveyor	-2.7897	2.5056
	Others	-1.5376	2.6495
Quantity Surveyor	Civil Engineer	-3.0515	2.2782
	Architect	-2.5056	2.7897
	Others	-1.8072	3.2033
Others	Civil Engineer	-3.2000	1.0306
	Architect	-2.6495	1.5376
	Quantity Surveyor	-3.2033	1.8072

Based on observed means.
The error term is Mean Square (Error) = 28.195.

Homogeneous Subsets

Impact

Scheffe[a,,b,,c]

PROFESSION	N	Subset
		1
Others	122	65.5820
Architect	87	66.1379
Quantity Surveyor	50	66.2800

Civil Engineer	84	66.6667
Sig.		.656

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = 28.195.

a. Uses Harmonic Mean Sample Size = 77.526.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. TProfessione I error levels are not guaranteed.

c. Alpha = .05.

PROJECT ROLE

Multiple Comparisons

Impact
Scheffe

(I) PROJECT ROLE	(J) PROJECT ROLE	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Contractor	Sub-contractor	.4524	.87675	.966	-2.0110	2.9158
	Others	.0156	.80480	1.000	-2.2456	2.2769
	Clients	.2459	1.09736	.997	-2.8374	3.3292
Sub-contractor	Contractor	-.4524	.87675	.966	-2.9158	2.0110
	Others	-.4368	.70140	.943	-2.4075	1.5339
	Clients	-.2065	1.02394	.998	-3.0835	2.6704
Others	Contractor	-.0156	.80480	1.000	-2.2769	2.2456
	Sub-contractor	.4368	.70140	.943	-1.5339	2.4075
	Clients	.2303	.96305	.996	-2.4756	2.9362
Clients	Contractor	-.2459	1.09736	.997	-3.3292	2.8374
	Sub-contractor	.2065	1.02394	.998	-2.6704	3.0835
	Others	-.2303	.96305	.996	-2.9362	2.4756

Based on observed means.
The error term is Mean Square(Error) = 28.195.

Homogeneous Subsets

Impact

Scheffe[a,,b,,c]

PROJECT ROLE	N	Subset 1

Sub-contractor	92	65.7935
Clients	38	66.0000
Others	152	66.2303
Contractor	61	66.2459
Sig.		.971

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = 28.195.

a. Uses Harmonic Mean Sample Size = 66.492.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. TProfessione I error levels are not guaranteed.

c. Alpha = .05.

Regression

Descriptive Statistics

	Mean	Std. Deviation	N
Impact	66.0904	5.28935	343
Likelihood	56.2536	6.12037	343

Correlations

		Impact	Likelihood
Pearson Correlation	Impact	1.000	.708
	Likelihood	.708	1.000
Sig. (1-tailed)	Impact	.	.000
	Likelihood	.000	.
N	Impact	343	343
	Likelihood	343	343

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	Likelihood[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: Impact

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.708[a]	.501	.499	3.74254

a. Predictors: (Constant), Likelihood

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4791.952	1	4791.952	342.121	.000[a]
	Residual	4776.247	341	14.007		
	Total	9568.198	342			

a. Predictors: (Constant), Likelihood

b. Dependent Variable: Impact

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	31.686	1.871		16.935	.000
	Likelihood	.612	.033	.708	18.497	.000

a. Dependent Variable: Impact

APPENDIX K: Personal Reflection

The 4 years of the PhD research has been an intense learning period which has changed my attitude and personal life. There was always so much to do in a short time and it seemed to be a task that would never end. The research journey has taught me how to conduct independent study and has also stretched my intellectual capabilities. There are many things I have learnt along this thesis writing journey which include effective thesis management and scholarly writing. With the support from my supervisors, I now have a better understanding of the research process, building arguments, and writing academic reports. Overall, I have learnt valuable life lessons from the PhD process. Although I was faced with several physical, psychological, and emotional challenges, there were some good experiences especially with respect to further developing my intellectual capability.